

CIN-157  
Task 2.1  
NAOCAA-D-2098  
Subtask 2.1.2  
Final Benchmarks

FL W.P.

# ASSESSMENT OF FISHERIES HABITAT

## FINAL REPORT

for

TASKS 1, 2, 3, 4, and 5

OCTOBER 1987

COASTAL ZONE

INFORMATION CENTER

These projects were supported by a grant from the Florida Office of Coastal Management, Department of Environmental Regulation, with funds provided by the United States Office of Ocean and Coastal Resource Management, NOAA, under the Coastal Zone Management Act of 1972, as amended.

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FINAL REPORT

for

GRANT PERIOD 10/1/86 THRU 9/30/87

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October, 1987

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SH329 .H344 1987  
21097913

FEB 4 1991

## INTRODUCTION

This report contains Tasks 1-5 of the Coastal Zone Management program at the Bureau of Marine Research. Task 1 work products focus on a project that relates potential environmental stresses (i.e., sediment, light) to physiological correlates (i.e., changes in amino acid pools, rates of oxygen production) of the seagrass, Thalassia testudinum. This work complements previous CZM work that identified environmental stress and loss of seagrass habitat as a major problem in long term resource management. Task 2 work products are centered around the development of the Marine Resource Geographic Information System (MRGIS) and the dissemination of both digital and hard copy data into the user community. Task 3 work products are based on the goal to link and quantify the relationship between fisheries species to estuarine habitats. Task 4 is accomplishing the goal of defining population dynamics of juvenile snook and red drum in a specific and quantifiable estuarine habitat to understand the complexities of population size, growth, mortality, immigration, and emigration. These three tasks now represent a major thrust of the Bureau of Marine Research to develop techniques and provide information to more effectively manage our marine resources.

Since sound information on habitat quantity, location, and importance to Florida's fisheries and non-game resources has never been addressed with a methodical, holistic approach, this type of information has not been available to the researcher or resource manager. Although much of what we are doing will require long term database development, the preliminary information has been and continues to be requested by agencies, planners, and researchers. We expect this program to grow and the knowledge gained to be of critical importance to the future of our coastal natural

resources.

Task 5 is providing the vehicle to get our information and project results to the general public. The most effective approach to resource management is by an informed public guiding the governmental processes. By providing factual non-technical information to the public, they can make better decisions when facing tough issues regarding our marine environment. Through brochures, presentations and other forms of media, we are accomplishing these goals and the results can only be positive for Florida's future.

## TASK 1: THALASSIA STRESS STUDY

Seagrass beds are important habitats for many species of fish and shellfish in Florida estuaries. However, dramatic loss in seagrass area was documented in most areas where habitat inventories were conducted. Seagrass habitat losses occur as the result of direct losses due to dredging and physical damage and indirect losses resulting from dieback. The causes of seagrass dieback are unidentified, chronic, and anthropogenic stresses, and turtle grass, (Thalassia testudinum), seems particularly susceptible to dieback. Field and laboratory experiments were carried out to (1) examine the potential roles of hypoxia and sediment sulfide concentrations in seagrass dieback and (2) to determine indices of chronic stress in Thalassia which might be used to identify stress in the field before a seagrass bed is lost.

### FIELD STUDIES OF COMMUNITY OXYGEN METABOLISM IN THALASSIA BEDS IN LOWER TAMPA BAY

#### Introduction

Diurnal measurements of community oxygen metabolism in healthy and stressed seagrass beds were undertaken in an effort to determine whether hypoxia causes or contributes to the phenomenon of dieback. Hypoxia frequently causes the death of flood-intolerant crop plants when soils are waterlogged for long periods of time, but one would not expect seagrasses, like Thalassia, to be prone to hypoxic stress.

Under all but the most extreme naturally-occurring conditions (ie., hurricanes), Thalassia is well adapted against hypoxic stress. The most prominent adaptation is the well-developed lacunar system which transports oxygen produced by photosynthesis in the leaves to the roots and rhizomes which are submerged in anaerobic sediment. We hypothesize that the capacity of this oxygen-conducting system can be saturated by high sediment BOD resulting from anthropogenic nutrient inputs, oxygen depletion due to sewage or nutrient inputs, or shading due to sediment resuspension or algae blooms.

#### Methods

To construct oxygen budgets for stressed and healthy Thalassia beds, four sets of diurnal measurements of oxygen metabolism were made at three sites in lower Tampa Bay. Measurements were made during the summer, on 6/30-7/2, 8/18-21, and 9/25-30, when high water temperatures enhanced possible hypoxic stresses.

The three study sites used for the diurnal measurements of benthic community metabolism were located in Fort DeSoto Park at the mouth of Tampa Bay (Fig. A). Sites were selected on the basis of previous studies carried out by this lab to represent extremes of water quality. The sewage-impacted site was located in a restricted embayment between St. Jeanne Key and Bonne Fortune Key, approximately 300 m north of the outfall for the sewage treatment plant serving the East Beach recreation area. The stress site was located east of Bonne Fortune Key in an embayment that had limited circulation, high water temperatures,

and generally high turbidity for most of the summer. The control site was located on the south side of Bunces Pass to maximize water quality by providing flushing and cool water temperatures.

At each site, four clear plexiglas chambers, 60 cm diameter x 50 cm height, were placed over the Thalassia bed. The chambers were sealed by pressing them into the sediment 5-10 cm. Water within each chamber was recirculated by a submersible bilge pump. A YSI Model 58 oxygen meter and probe continuously measured dissolved oxygen in each chamber, and a Li-cor LI-1000 data logger recorded mean, maximum, and minimum dissolved oxygen concentrations every 10 minutes for the entire logging interval. Photosynthetically-active radiation (light wavelengths from 400 to 700 nm) was recorded from one sensor above the water surface and another sensor at the top of the seagrass canopy. At the end of each experiment, root and shoot samples were harvested from each chamber to calculate biomass and leaf surface area.

Diurnal measurements at all three sites were generally made back-to-back on four consecutive days to minimize differences in weather between sites. Each cycle of measurements began at the stress site and ended at the sewage site. After the field measurements were complete, lab experiments were carried out to measure oxygen exchange rates of green leaves, epiphytized leaves, rhizomes, sediment, and overlying water from each site to partition oxygen fluxes measured in situ. Complete oxygen budgets were calculated for all four measurement cycles, but only data from the September series are presented below.

## Results

Diel oxygen flux measurements in September were made under virtually cloudless conditions (Figs. B, F, and J). Photosynthetically-active radiation (PAR) varied sinusoidally, with significant cloudiness during the morning of day two at the stress site and the afternoon of day two at the sewage site. Oxygen concentrations at the control site rose during the first three hours of measurement and then declined gradually from 1500 h until 1800 h (Fig. C). Rates of oxygen consumption in all four chambers increased after dark, and chambers were flushed with outside water at midnight to prevent anoxia. Post-flushing oxygen consumption rates were considerably higher than evening rates, probably as the result of rhizome oxygen depletion. Chambers were exposed by tides from 0630 to 0930. Upon reflooding, chamber oxygen concentrations rose rapidly until logging ended at 1200 h. Oxygen fluxes at the other sites (Figs. G and K) showed similar diurnal patterns.

When oxygen concentrations within each chamber are plotted against bottom PAR, latent oxygen storage and demands within the seagrass community become apparent (Fig. D). DO values lag behind PAR until approximately 0900 each morning suggesting an oxygen deficit within Thalassia or another major component of the system. Oxygen concentrations then rise rapidly for the remainder of the morning and oxygen concentrations in the chambers approach saturation in the late morning and early afternoon. Much of the oxygen produced at this time accumulates in bubbles or in lacunar tissue within Thalassia leaves, roots,

and rhizomes. As a result of oxygen storage in Thalassia, chamber DO values show little response to dropping PAR levels in the late afternoon and evening. Similar patterns are observed at the stress site (Fig. G) and the sewage site (Fig. K).

Community respiration at the control site caused rapid decreases in chamber dissolved oxygen levels (Fig. E). Non-linear oxygen consumption curves at all sites (see Figs. E and M) resulted from (1) the Pasteur effect resulting from first-order oxygen uptake kinetics at low oxygen concentrations and (2) oxygen transport through rhizomes from shoots outside the chambers.

Net photosynthesis, respiration, gross primary production, and the photosynthesis/respiration ratio for each chamber at each site were estimated from the oxygen flux curves (Table A). Net photosynthesis was highest at the sewage site, intermediate at the stress site, and lowest at the control site. Respiration was highest at the stress site and lowest at the sewage site. Gross primary production, estimated by adding dark respiration to net photosynthesis, was similar at the sewage and stress sites and lower at the control site.

Structural parameters used in oxygen budget calculations showed marked differences among sites (Table B). Root and shoot biomass at the control and stress site were similar but were quite low at the sewage site. Root/shoot ratios were 1.46 and 1.37, respectively, for the control and stress sites. The sewage site value, 0.64, probably reflected the minimal investment for producing belowground tissue in sediments with high biological

oxygen demand (BOD) and chemical oxygen demand (COD).

Shoot density, blade number, and maximum blade length were similar among sites. Blade width and green leaf area were highest at the control site, intermediate at the stress site, and lowest at the sewage site. Epiphyte leaf area was greatest at the sewage site, intermediate at the control site, and lowest at the stress site.

Component fluxes and total oxygen budgets for each chamber are shown in Table C. Sediment biological oxygen demand values were similar among the three sites, while the sediment COD values were quite different. Thalassia leaf respiration estimates were relatively low for the sewage site because of the small standing crop of seagrass present. Estimates of water column respiration rates were lowest for the stress site, considerably high for the sewage site, and highest for the control site. The component sum estimate of respiration is comparable for all three sites, but all three are considerably higher than chamber estimates for respiration. The discrepancy probably results from oxygen storage within Thalassia and transport of oxygen into the chamber from shoots outside the chamber during the field experiments.

Net photosynthesis of Thalassia was highest for leaves from the sewage site. Net photosynthesis in the water column was very high for the sewage site, intermediate at the stress site, and lowest at the control site. Component sum estimates of total net photosynthesis exceed chamber estimates by a factor of 3.1 for the stress site, 3.3 for the sewage site, and 4.2 for the control

site. These discrepancies also were attributed to oxygen storage in Thalassia tissue during field measurements and poor duplication of natural seagrass canopy light extinction characteristics in component measurements of photosynthesis.

### Conclusions

Field studies of community metabolism indicate, paradoxically, that while gross photosynthetic rates and photosynthesis/respiration ratios of Thalassia beds were highest in the sewage-impacted site, seagrasses at this site are extremely vulnerable to episodes of hypoxia and anoxia.

Several structural parameters may be useful indices of Thalassia stress based on the three sites we studied. Mean blade width was cited from other investigations as an indicator of salinity stress; we find that lower blade widths may also accompany oxygen stress. Root/shoot ratios may also be diagnostic of the BOD and COD characteristics of sediments.

## LABORATORY STUDIES OF THE RELATIONSHIP BETWEEN SEDIMENT SULFIDE CONCENTRATIONS AND THALASSIA GROWTH

### Introduction

The laboratory phase of this project examined the potential toxicity of hydrogen sulfide and its effect on the growth and survival of Thalassia testudinum. Sulfide was selected for study because it is a potent cytotoxin, rapidly denaturing metalloproteins (enzymes among them) when it diffuses into living cells.

Sulfide concentrations in the sediments of natural Thalassia beds are frequently very high, but this might play a synergistic role in seagrass die-back when plant roots become hypoxic. Root hypoxia may result from (1) natural causes, such as protracted cloudy weather which reduces the amount of oxygen transported from the shoots to the rhizomes and roots, or (2) anthropogenic causes, such as high sediment and water column BOD values associated with primary or secondary sewage effluent. When the root tissue becomes hypoxic, the leakage of oxygen out of the roots into the surrounding sediments ceases, and the immediate vicinity of the root surface (the rhizosphere) changes from a chemically-oxidized zone to a reduced zone. Sediment sulfide, which was oxidized by root oxygen in the rhizosphere, is then able to diffuse into the root tissue.

#### Methods

To investigate the effect of sediment sulfide on Thalassia growth, three experiments were conducted during the summer of 1987 in laboratory culture systems. The culture systems consisted of burial vaults filled with seawater located on the roof of the RMI building at the Bureau of Marine Research in St. Petersburg. Clumps of Thalassia and sandy sediment were collected in November 1986 from a healthy seagrass bed and potted with additional builder's sand into 50 1-gallon PVC pots.

Each of the three experiments lasted 4-6 weeks. The first experiment began 6/2/87 and ended 7/15/87. The second experiment began 8/1/87 and ended 9/4/87, and the third began 9/9/87 and

ended 10/14/87. While the last experiment occurred partly outside the contract period, the results are included in this report.

Light was measured continuously during all experiments using a Li-Cor datalogger and PAR sensor. Salinity and temperature of the water in each vault were measured twice daily and new seawater was used to restore salinities to values between 24 ppt and 30 ppt after rainstorms. During the second and third experiments, each pot was fertilized once a week with ammonium phosphate. Pore water sulfide concentrations were measured weekly during the first two experiments and twice weekly during the third experiment. During the first two experiments, no sediment amendments were made. In the third experiment, four treatments were randomly applied to three groups of pots. The three groups were assigned on the basis of initial sediment sulfide concentration: low = pots with sulfide less than 300  $\mu\text{M}$ , medium = pots with sulfide between 300 and 800  $\mu\text{M}$ , and high = pots with sulfide concentrations greater than 800  $\mu\text{M}$ . The four treatments were (1) bubbling sediment with air to oxidize sulfide, (2) twice weekly injections of sodium lactate to stimulate sulfate-reducing bacteria, (3) shading to reduce oxygen transport to roots and allow sulfide to penetrate the plant rhizosphere, and (4) controls.

At least five Thalassia short shoots were labelled in each pot, and all blades in labelled shoots were measured weekly between 5/2/87 and 10/14/87. Growth rates of each blade in labelled

short shoots were calculated each week during the interval. All statistical analyses were performed using SAS.

### Results

Despite the apparent homogeneity of the plant plugs collected for the experimental units, pore water sulfide in the 50 pots ranged from 10 micromolar to 3 millimolar. This serendipitous concentration span was used in the first two experiments to compare Thalassia standing crop to pore water sulfide concentrations (Table D).

No significant correlation was observed in any of the three experiments between Thalassia standing crop and pore water sulfide concentrations. While F-values for the regression models indicate a marginally significant relationship between sulfide and plant standing crop for experiment 2, the correlation coefficients suggest a very weak relationship. The highest r-squared value (0.14) was obtained during experiment 2 when the log of total blade length at the end of the experiment for each pot was regressed against mean pore water sulfide concentration during the experiment (Model 4, Table D). Relationships between growth rates and pore water sulfide concentrations in experiments 2 and 3 were also weak, but were improved by the addition of initial total leaf standing crop as an independent variable in the regression model (Models 9 and 14, Table D).

Manipulation of the sediment environment in experiment 3 resulted in marked changes in pore water sulfide concentrations and marginally-significant changes in leaf growth rates (Table E).

High and medium sulfide groups in the control treatment showed slight declines in pore water sulfide during experiment 3, while the low sulfide group in the control treatment showed a slight increase in sediment sulfide. Aeration caused marked declines in the sulfide concentrations of high and medium sulfide groups, but a moderate increase in the low sulfide group. Lactate addition caused a marked increase in the sulfide concentration of high sulfide pots and a moderate increase in medium sulfide pots. Sulfide concentrations declined dramatically in all the pots that were shaded. Turnover times varied slightly among treatments and groups, but the decrease in sulfide concentrations and lack of increase in turnover time observed in the shade treatment suggest that Thalassia is definitely light-saturated and may be inhibited in full sunlight.

### Conclusions

We were unable to demonstrate a significant effect of sulfide on Thalassia growth rates under laboratory conditions. However, the apparent light-saturation and possible photo-inhibition observed in experiment 3 suggest that experiments proposed for FY 87/88 funding, examining the interaction of light and sulfide concentration, should give us valuable results.

## TASK 2: MARINE RESOURCE GEOGRAPHIC INFORMATION SYSTEM UPDATED AND CLASSIFIED IMAGERY

A major update and restructuring of the primary LANDSAT database of the MRGIS was accomplished during this grant period. The original database was not designed for the flexibility now required for data dissemination. The demand for quantitative and geographically oriented data has increased tremendously within the private and government sectors. When the MRGIS was originally conceived and developed it was designed to house fisheries habitat data. From our perspective, this meant a final form of data which could be integrated into the development of fisheries carrying capacity models. Our approach was successful in creating a fisheries habitat database, but this approach did not lend itself to the flexibility needed to provide data to a user community. We used a biased statistical approach to delineate the fisheries habitat at the expense of the non-fisheries habitat (Fig. 1). With this approach we maintained the database on three 300 megabyte disk packs. Once the raw data were processed, it was deleted and maintained on the original 9 track tape data set. Reaccessing the raw data to meet additional needs that were not originally perceived was, therefore, time consuming and cumbersome. Many other problems were inherent in this approach from a data access and dissemination perspective.

The new and flexible approach we have taken is depicted in Figure 2. Georeferencing is done on the raw data. This allows us to generate products in the UTM format with no margin of error in geoposition from one product to the other. In addition, the algorithm used for georeferencing the raw data is a bilinear interpolation and maintains the resolution of the raw data much better than that of the nearest-neighbor algorithm used

to georeference classified data. The georeferenced raw data are maintained on active 300 Mb disk packs. A parallel-piped classifier is run on the data to create two intermediate data sets. The first data set is the result of classifying Bands 2 (green), 3 (red), and (4) red/near infrared into 256 categories. The second data set results from classifying Band 3 (red), 4 (red/near-infrared) and 5 (mid-infrared). The first classification best depicts general land cover while the second classification enhances wetlands delineation. Since 256 numerical categories exist in each data set, over 500 categories can be evaluated and combined to best present the needed final work file database. This increases the time required to generate the final product and requires more interactive interpretation of the data but the results are superb to any other methods we have tested. The versatility of this approach allows us to meet all the demands on the types of information desired. For example, boundaries for resource maps for the Aquatic Preserve program are based on ordinary high water and require only one category for saltmarsh. A county, on the other hand, may be interested in separating the marsh into four categories (Juncus sp., Spartina alterniflora, Spartina bakeri, and mixed saltmarsh). Fisheries habitat researchers may be interested in not only species delineation but also density differences. The point is that everyone requires information tailored to their own needs and if the database is not versatile enough to handle these requests, it will be of limited value. We feel that we are now in a position to service many types of requests.

Through this approach, we increased our actively maintained data from storage on three disks (.9 gigabytes) to a current inventory of 17 disks (5.1 gigabytes). Each disk represents a region of the state and the data

can be accessed on the MRGIS within five minutes by simply placing the disk into the disk drive. We structured all data for coastal Florida in that format except for the lower portion of the Indian River Lagoon. This has not been done because we were unable to acquire a good, cloud-free Thematic Mapper image of the area; however, an image for the area was recently ordered. When it arrives, the coastal database for fisheries resources will be complete. In summary, we have updated and classified the entire fisheries habitat database for the State of Florida, not just the areas originally specified, in a much more versatile format.

#### DATA DOWNLOADING

The interest in accessing the MRGIS database has virtually expanded beyond our ability to respond in a timely manner. This was a primary reason for our efforts in data updating and restructuring. We met all the obligations outlined in our grant for data downloading and met many additional data requests.

Digital data was transferred to East Central Florida Regional Planning Council (ECFRPC) in several formats. The Cocoa/Rockledge area was processed on the MRGIS using a parallel-piped classifier with two different channel analyses. These data also were run through a mode filter which reduces the number of isolated pixels in the data. In addition, a maximum likelihood classifier was run on the raw data; this and a mode filtered version were transferred to the ECFRPC. By providing this versatility in data formats, the ECFRPC then was able to determine which format(s) best provided the information they required. Seagrass and mangrove delineations were provided in the downloaded data. We also provided the Wekiva River area in several processed forms.

Processed data in several formats were also transferred to the GIS at Rookery Bay Aquatic Preserve in Naples. The data were consolidated and ground truthed and returned for hard copy production and storage on the MRGIS (Figs. 3 and 4). This series of transfers demonstrates a major concept in the long-term development of the MRGIS. It is our feeling that digital data transfer is the most efficient and usable format of the MRGIS database. The micro-computer environment provides an effective means to address that method of transfer. In the case of the Naples facility, in-house expertise was employed to consolidate the fisheries habitat data and conduct ground truthing. The final products were then transferred back to the MRGIS for final preparation and storage. An extensive network of this nature throughout the state would provide an effective means for database development, maintenance, and enhancement. We also provided data to the Naples facility that depicted sand beds off Marco Island.

Digital data also were transferred to the Marine Resources Council of East Central Florida who recently acquired the necessary micro-computer equipment for image data manipulation and to DNR Bureau of Aquatic Plant Management who also recently acquired similar capabilities.

The Everglades National Park personnel are in the process of acquiring MRGIS-type capabilities and have substantially completed a mapping of fisheries habitat. We currently have a hardcopy form of their maps. We do not plan to digitize this into the MRGIS unless their funding is cut, but we will access their database and provide assistance in the development of their system. This is also true with Kennedy Space Flight Center; they recently acquired a GIS that is compatible with the MRGIS and we will have direct access to their data.

Finally, digital data were also provided to the South Florida Water

Management District, University of Florida IFAS Remote Sensing Lab, University of Florida Northeast Regional Data Center, and Florida DOT Bureau of Topographic Mapping.

Over the last funding year, we provided the Aquatic Preserve Program with hard copy resource maps for Ten Thousand Islands (Fig. 3), Rookery Bay (Fig. 4), St. Martins Marsh (Fig. 5), Tomoka Marsh (Fig. 6), Wekiva River (Fig. 7), and Big Bend (Fig. 8) Aquatic Preserves. Wekiva River Aquatic Preserve was our first major effort using Thematic Mapper data to inventory freshwater wetlands. The Big Bend area was the largest Aquatic Preserve we inventoried and presented us with special challenges to produce the preliminary hard copy map. The Big Bend area was composed of three different LANDSAT scenes from different time periods and was housed on three different disk packs because of the massive volume of data. The data were standardized numerically, transferred to a single disk, and then geographically joined into one large 21 megabyte file. The transfer of this large file onto the IBM-AT, which has the printing capability, was not attempted because of storage space problems. This transfer will occur after we acquire large mass storage capabilities on the micro system. We had to reduce the data by 60% in order to transfer and plot it (Fig. 8). This was a logistical problem that will be rectified in the near future.

The inkjet hardcopies for this report are presented in large-scale for convenience. Figure 9 is a full resolution print of a portion of Figure 6 to provide an example of the resolving capabilities.

The above digital and hardcopy dissemination efforts were planned and time-budgeted for completion within the framework of our proposed work schedule. We additionally have been deluged with requests for fisheries habitat data to meet the requirements of local and regional comprehensive

growth management plans. These requests (Table 1), along with many others, continue to accrue and only a portion of them have been satisfied. The quantity of information requests prompted us to restructure the data (Fig. 2) to better accommodate the requests. From a coastal resource management and fisheries management perspective, we believe that the long-term success of the MRGIS will depend on our ability to meet these requests. More importantly, the dissemination of these data (particularly resource inventory maps) is a very basic step in effective fisheries resource management.

In addition to providing resource maps, analyses of land use changes were conducted of the Delaney Creek and Frog Creek watersheds in Tampa Bay for the Tampa Bay Regional Planning Council. A series of hardcopy maps were produced which delineated specific categories of land use change and associated acreages.

A black and white image of a portion of Tampa Bay (Fig. 9A) was produced on request by the Office of the Auditor General. The image depicts an example of seagrass loss in Tampa Bay. This image demonstrated the capability to produce a simplified black-and-white print out of an MRGIS data set. In addition, it demonstrated the combining of overlays to show both seagrass present today and that which was present in 1948.

Numerous informal and formal presentations were given on the CZM project at workshops, meetings, and conferences (Table 2). Numerous interviews were conducted for newspaper articles; most are included within Attachment 1. Local television interviews also were conducted. Special filming of the MRGIS habitat loss information was conducted for a one-hour PBS program called "Walking Trees" and for a Discovery (Boston PBS) program on manatees. A non-technical article by Bruger and Haddad (Attachment 2)

is being published as a chapter in Jurisdictional Management of Marine Fisheries. The MRGIS was visited by and demonstrated to 1) federal, state, regional and local agencies, 2) private citizens and companies, 3) research scientists, 4) university staff, 5) state legislators, and many others. The number of requested visits and the amount of advice requested by phone has proven to us that the MRGIS concept and development is now perceived as an example of successful implementation of GIS technology and reflects positively on the Coastal Zone Management effort in Florida.

#### ANCILLARY DATA DEVELOPMENT

Ancillary data development was curtailed to accommodate the data restructuring and dissemination efforts. Again, it is our contention that effective dissemination of data will have an immediate effect on the long term management of Florida's marine resources. The State of Florida is emphasizing growth management and, other than the MRGIS habitat database, very little information exists that documents the location and extent of marine resources/fisheries habitat. It is imperative that this information be available for development of growth management plans.

In addition, we encountered some logistical problems in locating and consolidating data to be entered into the MRGIS. We were fortunate to have a concerted, multiagency effort to consolidate the various data overlays into map form for the Tampa Bay area. This is not the case for other Florida estuaries. A Charlotte Harbor database overlay set was built by the U.S. Fish and Wildlife Service National Wetland Research Center as part of their manatee program. We previously developed software to access their database and we are arranging to have that data set transferred to the MRGIS. It is our general intent not to duplicate effort in the MRGIS

database development and we will continue to access existing digital data where available.

We completed a drainage basin analysis for land-use changes of the Indian River Lagoon and additionally digitized the majority of seagrass delineations from previously contracted CZM work to Brevard County and Robert Virstein. We lack the updated lower Indian River Lagoon Thematic Mapper data but, as stated earlier, recent imagery has been ordered. Ongoing studies by the St. Johns Water Management District, South Florida Water Management District, Florida Institute of Oceanography, and Bionetics/NASA are being conducted to consolidate data on the Lagoon. Much of the data will be incorporated into the MRGIS. We are working with these different entities to make the data compatible in digital form. FIT and Bionetics are developing digital GIS systems compatible to the MRGIS and digitizable maps for easy transfer to the MRGIS.

We developed special overlays for several areas in cooperation with local and regional entities. In general, we agree to digitize data into the MRGIS for quantitative analyses with the understanding that the data becomes a part of the MRGIS. This allows us to gain up-to-date data with minimal effort and provides the participating organization with needed information. An updated and detailed seagrass analysis for Sarasota Bay was completed using this approach and we expect this type of arrangement to continue.

Two papers were presented at the Coastal Zone 87 conference in Seattle which demonstrated the MRGIS data overlay capabilities and the utility of the MRGIS. The first paper dealt directly with the GIS process and concepts (Attachment 3). The second paper (Haddad, K.D. and D. Ekberg, the potential of Landsat (TM) imagery for assessing the national status and

trends of important coastal habitats) used overlays of TM data and USFWS data that were converted to raster format to assess potential problems of using TM data to update the National Wetland Inventory database. Final reprints have not been received and, thus, only a copy of the GIS paper is included in this report.

#### LINK OF TABULAR DATA TO THE MRGIS

A basic long-term need for effective Geographic Information System development is a link and access mode to tabular data which are based on single-point geographic locations. The general approach in the past has been to summarize GIS data and port it to a tabular database for statistical analyses or report generation. Those GIS systems that include tabular information in their analyses generally require the entire map and tabular data to be in a special format and maintained as such. We believe that the power of a GIS lies in its versatility in data manipulation. The less the user must restructure data, the more efficient the system. In addition, we believe the transport of data into a GIS is the most effective direction of data flow.

During this grant period, specific software was developed to interface to a multitude of outside tabular databases. We chose an industry standard software interface by developing the ability to access DBAS III+ files. Many organizations, including DNR, DER, and National Marine Fisheries Service, are using DBAS III in a micro-computer environment to enter and retrieve data from a mainframe. By tapping into this conduit, we tremendously increased the power of the MRGIS. A schematic (Fig. 10) of the process depicts this general approach. We purposely built the link in the micro-computer environment for long-term compatability to any DOS-based

system. A module (DB34) was created in ELAS which offers a variety of ways to access DBAS files. The latitude/longitude of the given record in a file is the main link from a DBAS file to the MRGIS. The DBAS file search by the MRGIS is based on the geographic data boundaries on the graphics display device. Only one field of information can be transferred to the MRGIS display at a time. These data can be stored as an overlay and another field of information can be accessed. The process was successfully tested with fisheries statistics data and is currently being used to assess distributions of manatee sitings and mortalities for presentation to the Governor and Cabinet. The methods developed to implement this phase of MRGIS development were extremely successful, extending the utility and versatility beyond the original link to the fisheries statistics data.

### TASK 3: HABITAT CARRYING CAPACITY

#### GEAR TESTING METHODS

This task continues a major thrust to construct and test sampling gear that are capable of providing quantitative assessments of living marine resources. Considerable effort was required to design and build prototype gear, test it, and then refine the gear before the actual gear comparisons could be made. Much of the gear design and refinement was accomplished during the first half of the year and involved gear construction contracts, in-house construction, net sewing, testing the mechanics of each gear, redesigning, retesting, evaluating net mesh sizes and types, reviewing and incorporating existing designs, and a multitude of logistical procedures.

Actual, comparative gear testing began in June, 1987 and was conducted weekly. The sampling site chosen for the gear study was adjacent to Tarpon Key, a small mangrove island (approximately 50 acres) located in Tampa Bay between the Sunshine Skyway and Mullet Key (Fig. 11). This site provided an extensive homogenous distribution of dense Thalassia testudinum surrounding the island, imperative for repetitive gear sampling. Although a different area was sampled during each sampling trip within the Tarpon Key study site, we assumed homogeneous organism distribution.

The following information was recorded at each sample station: date, time, tidal stage, lunar stage, wind direction and speed, and % cloud cover. Water and air temperature, salinity, dissolved oxygen, pH, and water depth were measured with a Hydrolab surveyor II. Gear soak time and/or area sampled were recorded when applicable.

Fish and macroinvertebrates (Callinectes sapidus and Penaeus sp.) were sorted, identified to species, measured, and returned to the water.

Measurements included standard length of fish, carapace length of shrimp, and carapace width of crabs. If a large number of one species was collected, a subsample of 20 random individuals was measured and the remainder was counted. Amounts of macroalgae and seagrass captured in the shrimp trawls and otter trawls were also recorded. Data were entered and analyzed using SAS (Statistical Analysis System) programs. !

#### Gear Descriptions

The sampling gears utilized for this comparison study included tripod drop nets, boom drop nets, roller shrimp trawls, and an otter trawl.

Tripods. Three tripods (Fig. 12) were constructed of 16' long, 2" diam. aluminum pipes which were connected together by an aluminum plate (3 1/2" diam.) at their upper ends. These tripods were similar to those described by Gilmore et al. (1978). After preliminary testing, it was concluded that smaller, lighter tripods made of 1" diameter aluminum pipes provided the strength necessary to lift the 4m<sup>2</sup> drop net, and were also much more manageable by the field crew. A total of six lighter-weight tripods were then constructed totalling nine tripods altogether.

The release mechanisms (Fig. 13) for the tripods were similar to those described by Gilmore et al. (1978). Dacron line (1/4" diam.) was attached to a #3 brass clip that was linked to the four corners of the drop net by stainless steel wire (1/16" diam.). The line traveled up through a pulley at the top of the tripod and connected to a 2" galvanized ring at the other end. This ring, when set into a release mechanism, held the nets in place. A trip cord (1/8" dacron line) was connected to the release mechanism and anchored approximately 100' from the set tripod. A pull on this line released the drop nets.

Nine drop nets (Fig. 14) were constructed: three 1m<sup>2</sup>, three 2m<sup>2</sup> and three 4m<sup>2</sup>. These nets were similar in design to those described in the 1986 CZM Final Report. They were fixed with an upper float frame constructed of PVC pipe (2.5 cm diam. for 1 and 2m<sup>2</sup> nets, and 5.0 cm diam. for the 4m<sup>2</sup> nets). The lower sink frames were constructed of stainless steel; the 1m<sup>2</sup> sink frames had 25 mm frames (identical to those described in the 1986 CZM Final Report) and the 2 and 4m<sup>2</sup> nets had wider sink frames for greater stability, 38 mm and 50 mm wide respectively. The frames were connected by 1.5m length of nylon ace 1/8" netting. A 3/16" galvanized chain line was suspended 6" below the perimeter of the sink frame with 1/8" netting to reduce the chances of fish escaping if the sink frame dropped on an uneven surface.

Tripods were erected from the stern of a 23' mullet skiff to reduce disturbance of the bottom vegetation. At least three people were necessary for this procedure. Tripods were allowed to stand for approximately one hour before release of the nets. Upon release, lower frames were checked for a level drop then pressed into the sediment. An internal seine of 1/8" mesh (described in the 1986 Final Report) was used to remove fish and macroinvertebrates from the enclosed area. Each seine was slightly smaller in width than the drop net frames. The seine was pulled through each drop net eight times, twice on each frame side. If an organism was captured on the eighth pull, three additional pulls were repeated until three consecutive hauls captured no fish.

#### Boom Drop Nets

Two 1m<sup>2</sup> nets (Figs. 14 and 15) were dropped simultaneously off the bow of a 17' Boston Whaler. Construction and deployment of this gear was

described extensively in the 1986 CZM Final Report.

#### Roller Rigged Shrimp Trawls

Two roller trawls were constructed from galvanized and stainless steel (Fig. 16). The mouth of each trawl was 5' wide and net length was 10'. Upper netting, measured diagonally knot to knot, was 3/4". Cod end netting was 1/8" nylon ace netting, identical to that used in the other sampling gears. A 5' roller was attached to the rear of each trawl so the gear rolled over the sampling area without damaging the seagrasses.

A 16' long, 2" diam. aluminum pipe was attached with brackets just anterior to the console of the 17' Boston Whaler (Fig. 17). Rope attached to the front of the roller trawls ran through eyebolts in the pipe and around the bow of the whaler. Trawls were towed midway between the bow and the stern, at a slight angle (approximately 30°) to allow organisms to enter. Stainless steel 'rakes' on the trawl kept macroalgae from filling the net.

Nine preliminary tows were conducted at 1300, 1500, and 1700 RPM to determine optimum towing speed for these trawls on the 17' Boston Whaler. The maximum speed the trawls could be towed without pulling them off the bottom was 1700 RPM. Also, number of fish captured at 1700 RPM was markedly larger than those captured at 1300 or 1500 RPM.

Trawls were towed over a distance of 100 m. Time of tow was recorded and the cod-ends were pulled onto the back of the boat and emptied into two 30-gallon containers. The samples were processed immediately. Each trawl covered an area of 152.5m<sup>2</sup> for each 100 m tow.

#### Otter Trawl

The otter trawl (Fig. 18) had a mouth opening of approximately 4m.

The entire net was 20' long. The otter trawl had a body of 1" mesh, measured diagonally knot to knot, and 1/8" ace netting in the cod-end. The net was towed 50m from the stern of a 23' mullet boat by 3/4" nylon rope which split to 2 ropes at a bridle, allowing the doors of the trawl to spread apart. The trawl was towed at 1300 RPM over a distance of 50m. (Preliminary tows covering 100m produced an over-abundance of catch. A decision to shorten the transect from 100m to 50m was enacted early in the program.) Time of tow was recorded and the cod-end was emptied into one or more 30-gallon containers. The samples were processed after the three tows were conducted.

#### RESULTS

A total of 26 fish species and numerous invertebrate species were collected during this study, however, the blue crab (Callinectes sapidus) and the pink shrimp (Penaeus duorarum) were the only invertebrates examined quantitatively.

Area covered by each gear type differed greatly. The 6.1 m (20 ft.) otter trawl covered the greatest area: 200 or 400m<sup>2</sup> for a 50 and 100m pull, respectively. The roller shrimp trawls covered 152m<sup>2</sup> per 100 m trawl. The drop nets covered areas of one, two, or four m<sup>2</sup>.

Because of the large difference in area covered by each sampling method, examination of actual numbers of fish and invertebrates captured by each method would give a biased indication of gear efficiency. However, density of the organisms captured by each sample gear should provide a more useful method of gear comparison. Density was analyzed by determining the number of organisms/m<sup>2</sup> captured by each of the gears (Table 3). The roller trawl estimated the smallest number of organisms/m<sup>2</sup> with a mean of 0.42.

The 6.1m otter trawl caught approximately 1 organism/m<sup>2</sup>. All of the drop nets gave much larger estimates of organism density, with the 1m<sup>2</sup> boom drop nets giving the highest density, mean = 6.36 organisms/m<sup>2</sup> closely followed by the 2 and 4m<sup>2</sup> tripod drop net estimates. Variability in the density estimates can be examined by observing the coefficient of variation of each gear (CV = 100 (mean/SD)). Of the drop nets that gave the highest density estimates, the 2 and 4m<sup>2</sup> tripod drop nets have a markedly lower variability than the 1m<sup>2</sup> boom drop net and, therefore, would require smaller sample sizes to estimate abundance.

Diversity of organisms captured by each gear type was analyzed. Twenty-five of the 26 fish species were captured with the 6.1m otter trawl, 16/26 with the roller shrimp trawls, 14/26 with the 4m<sup>2</sup> tripod drop nets, 12/26 with the 1m<sup>2</sup> boom drop nets, 11/26 with the 2m<sup>2</sup> tripod drop nets, and 9/26 with the 1m<sup>2</sup> tripod drop nets. There appears to be a general trend of increasing diversity of organisms captured as the sample area covered by each gear increases; with increasing sample area, chances of encountering less common species increases. Diversity estimates of number of species/m<sup>2</sup> have been determined for each gear type (Table 3). The drop nets, both tripod and boom, captured approximately 2.5-3.5 species/m<sup>2</sup> while the trawls captured .03-.04 species/m<sup>2</sup>. The species of fish and invertebrates collected by each gear type are listed in Table 4. Seven of the species collected were captured by each of the gear types including the gulf toadfish (Opsanus beta), gold-spotted top minnow (Floridichthys carpio), rainwater killifish (Lucania parva), gulf pipefish (Sygnathus scovelli), mojarra (Eucinostomus sp.); pinfish (Lagodon rhomboides), and the clown goby (Microgobius gulosus). The most common fish captured throughout the study period was the rainwater killifish. This fish comprised over 60% of

the fish captured with the 1 and 4m<sup>2</sup> tripod drop nets and the 1m<sup>2</sup> boom drop nets, and close to 50% of the remaining gear types (Table 5). The remainder of the fish species captured differed in percent dominance by gear type, but generally included pinfish, mojarras, and the clown goby. The inland silverside (Menidia beryllina) is listed as the second most common fish collected with the 2m<sup>2</sup> tripod drop net. This pelagic fish occurs in a clumped distribution and the large number of these fish captured in 1 or 2 drops biased the results of the 2m<sup>2</sup> tripod drop net. Increasing the number of drops would reduce the occurrence of this type of bias. The pink shrimp was captured with each gear type while the blue crab was collected in each gear except the 1 and 2m<sup>2</sup> tripod drop nets.

Preliminary analysis of a one-night sampling trip indicated that the number of pink shrimp captured at night with the roller shrimp trawls was markedly larger from the number caught during the day. Pink shrimp made up 0.4% of the fish and invertebrates captured during day sampling, but if the night sampling data is included with the day sampling data, the pink shrimp comprise over 16% of the organisms collected (Table 5). This trend is not as readily apparent with the other gear types and additional night samples must be collected before adequate analysis is possible.

Many of the species captured with drop nets (tripod and boom) are the slow moving, demersal types such as the code goby and the clown goby. An interesting situation occurs when examining the tripod drop net catch of these organisms. The code and clown gobies respectively make up 11.6% and 5.8% of the catch of the 1m<sup>2</sup> tripod drop net, 6.6 and 5.5% of the 2m<sup>2</sup> tripod drop net, and 2.8 and 2.5% of the 4m<sup>2</sup> tripod drop net (Table 6). Whether this decrease in estimated percentage of small demersal fish is due to the increase in number of other species captured with the larger net or

decreased efficiency at sampling larger nets with larger seines will be examined. Efficiency of each of the drop nets will be tested by releasing a known number of fluorescently marked fish of a number of species into the dropped drop nets and allowing these fish time to equilibrate. The nets will be seined according to the procedure described earlier. Preliminary findings of efficiency testing with L. parva released into 1 and 4m<sup>2</sup> drop nets indicated recapture efficiencies at 88% and 84% respectively. More replicates will be conducted with fish species such as the pinfish, clown and code gobies and the pink shrimp in order to determine seining efficiency.

Average density for the seven fish species common to all gear types is listed in Table 7. The only species captured by the otter trawl in similar numbers to those captured by the drop nets is the pinfish. The roller trawl produced density estimates much lower than the other gears. The slower moving, demersal fish species like O. beta, L. parva, S. scovelli and M. gulosus are captured more effectively with the drop nets while it appears the trawls may ride over these species, especially in areas of dense Thalassia. The more semi-demersal and pelagic species such as the pinfish and mojarras are captured almost as frequently with the trawls as with the drop nets. These fish swim higher in the water column and are more susceptible to capture by gears such as otter or shrimp trawls which can rapidly sample large areas of the water column.

An attempt was made to compare average fish length (SL) between gear types (Table 8). The data suggest a trend in the otter and roller trawls capturing larger fish than the drop nets, however, more replicates are necessary to confirm this because of the small sample size of the drop net species.

## DISCUSSION

Each gear type tested in this study was selective in its capture of different organisms. Hartman (1984) compared six estuarine sampling gears and found that although the otter trawls were easiest to use, the fewest fish and lowest density of organisms of all but a few important species were captured. Kjelson and Johnson (1973), using a 6.1m otter trawl, estimated catch efficiencies for juvenile and yearling pinfish and spot (Leiostomus xanthurus). For pinfish, efficiency of capture was 48-49%, and with spot, 32% of marked fish were recaptured. Our sampling indicated that the otter trawl captured the greatest number of species (n = 25 of 26), but species density resulted in less than .04 species/m<sup>2</sup>. Also, because of the greater area sampled with the trawls with less efficiency, organism density was much lower than those predicted with the drop net data.

The roller shrimp trawl gave the lowest density and diversity estimates of fish/m<sup>2</sup>, but may be useful in estimating the abundance of penaeid shrimp, especially when this gear is used at night.

Recently, drop nets were used in studies to quantitatively sample organism abundance and diversity in the estuarine environment. These include studies by Jones et al. (1963), Jones (1965), Moseley and Copeland (1969), Kjelson and Johnson (1973), Kushlan (1974), Kjelson et al. (1975), Gilmore et al. (1978) and Fonseca (personal communication).

Kjelson et al. (1975) discussed some major limitations of drop nets: small sample size, small number of samples/unit time, and the bias created when organisms avoid or are attracted to the net or frame. A small sample size is limiting, particularly for fish of lesser abundance and those with a clumped distribution. Gilmore et al. (1978) found that the drop net captured fewer individuals and species than a seine and the species were

mostly small demersal and semidemersal forms. However, they found that total fish density and biomass values from the drop net surpassed the seine. Actual values of fish density for Gilmore et al.'s drop nets ranged from 1.8-19.3 fish/m<sup>2</sup> ( $\bar{x}$  = 9.0). Our estimates from tripod drop nets were very similar. For example, density estimates from the 2m<sup>2</sup> tripod ranged from 1.5-17.5 organisms/m<sup>2</sup> ( $\bar{x}$  = 6.07). Kjelson et al. (1975), using a 4m<sup>2</sup> drop net, compared density and diversity estimates with that of a 525m<sup>2</sup> haul seine. The haul seine captured more species, but the drop net yielded estimates of significantly higher density of fish and macroinvertebrates. Kushlan (1981) estimated the accuracy of 1m<sup>2</sup> throw traps in the Everglades at about 73%. This value is much higher than those estimated for otter trawl efficiencies of 32-50% (Kjelson and Johnson, 1973).

Comparisons of drop nets (tripod and boom) with the trawls (otter and roller) in this study suggest similar conclusions to those above. Drop nets captured a larger density and a greater diversity of organisms per m<sup>2</sup> while the trawls were more effective at capturing less common species.

#### CONCLUSION

Preliminary gear testing was completed with four sampling gears used to sample the shallow seagrass environment. In the upcoming year we will determine the efficiency of the three sizes of tripod drop nets. Our goal is to determine the drop net size that is easiest to use and provides the most accurate estimate of community structure. At this time it appears that the 1m<sup>2</sup> drop net, which gives the lowest estimate of density and diversity and has the largest coefficient of variation, could be discontinued. The 4m<sup>2</sup> and 2m<sup>2</sup> tripod drop nets had very similar density

and diversity estimates and also had relatively low variability between each drop. The 4m<sup>2</sup> drop net is particularly cumbersome to handle and if these 2 and 4m<sup>2</sup> nets provide similar results, it may be possible to eliminate the 4m<sup>2</sup> net. However, further efficiency testing with marked fish will be necessary to determine our sampling efficiency with the internal seines once the nets have dropped and this also will contribute to our decision to use a specific drop net size. We will continue to sample during day and night. Further night sampling is necessary to indicate differences in number or species of fish or invertebrates captured on a diel basis and to determine if the roller trawl provides a good indication of Penaeid abundance. Our preliminary data suggest that average size of fish captured by the trawls may be greater than that of those captured with the drop nets; we will continue this study to determine whether or not this is true.

Initial results suggest that our goal is attainable - we will be able to develop a carrying capacity model based on using quantitative data gathered by a combination of gear collection methods. New gear types and refinements of existing methods will certainly occur to accomplish this task, but this initial phase is encouraging. We built or are building additional gear (i.e., breeder traps, stop nets, multimesh gill nets, and small purse seines) to further pursue a multihabitat multi gear approach to quantitative sampling, but statistical testing of these gear has not been completed. We expect to accomplish much of the gear testing this coming year along with a rigorous sampling schedule using existing techniques in the Cockroach Bay/Little Manatee River area.

## CARRYING CAPACITY MODEL

We continued to evaluate existing models that use an environmental approach to projecting fisheries abundance. It appears that a number of separate models must be integrated into the MRGIS to develop population estimates. We have not pursued the actual model construction because a sufficient database does not exist to generate all of the different model inputs. The next year study on the Little Manatee River/Cockroach Bay watershed will provide the most complete data overlay compilation ever developed (from a fisheries perspective) and will provide a base for constructing and testing a carrying capacity model. The model development will require multidisciplinary cooperation among biologists, geologists, hydrologists, physicists, and ecologists to link integral parts of the overall model. The development of this model will co-evolve with the database required to test and verify the model. It is important to note that the model we are developing will be designed to input real data as opposed to those that make assumptions on recruitment, mortality, etc. Also, the model will use environmental and geographic parameters to define population distributions and will only be valid for estuarine-dependent species. We are actively working with the DNR Fisheries Statistics Section to develop the database and conceptualize the model integration. As we progress with each phase of development, the approach will become more multidisciplinary and complex and only a computer system such as the MRGIS will be capable of integrating this needed information.

#### TASK 4: JUVENILE HABITAT UTILIZATION

The objective of task 4, was to determine the aspects of the population dynamics (population size, growth, mortality rates, immigration and emigration) of juvenile red drum and snook in a specific estuarine habitat. The habitat chosen was a small undeveloped man-made canal. There is only one entrance which makes monitoring movement somewhat simpler. Red drum and snook were targeted because both were abundant in the canal in previous work and DNR is establishing a hatchery which will be producing juvenile red drum and snook for release into the wild. Population dynamics data are needed to better understand the results of hatchery releases into the wild.

Two years of juvenile snook and red drum data have now been generated from the canal research. Unfortunately, few snook were collected and, because of this lack of sufficient collections, little analysis was done. However, from the snook that were collected, population estimates were made using density (the number of fish collected per  $m^2$ ). This technique suggested that the canal only supported a maximum population size of 280 individuals. The highest population values occurred during late summer and fall. There were too few marked snook released into the canal and too few recaptured to estimate population size utilizing mark-recapture techniques. Snook recruitment, during 1986, started in July and continued into December.

Only one juvenile snook was collected in the canal through 23 September from the last spawn.

Juvenile red drum were collected in adequate numbers for more detailed analysis. Standing crop was estimated in two ways. One was a mark-recapture method where fish were marked with fluorescent pigment granules injected under the epidermis. The second method expanded the mean density per haul to the area of the entire canal. The canal is quite uniform throughout and red drum have been collected from all areas. Weekly seining trips consisted of 12-16 hauls per trip with each haul encompassing 71 m<sup>2</sup>. Twelve hauls covered approximately 11% of the total canal area at mean tide. In order to accurately estimate standing crop using seining techniques, efficiency of the seine must be determined. This was done by introducing marked fish into the seine after it was deployed. The percentage returned is then used as an estimate of efficiency. The mean seining efficiency for red drum in this canal was 83% and ranged from 68% to 95%. This mean value was then used as a correction factor in calculating standing crop.

Standing crop estimates are shown in Figure 19. All years are combined to show overall trends. Similar trends and values were seen in both years. Also shown in Figure 19 (circled values) are the standing crop estimates based on mark-recapture data.

Largest population estimates occurred in December and January during both years. Standing crop steadily declined the rest of the winter and through the spring until there were few fish remaining during the summer.

In order to estimate mortality, information on immigration and emigration is needed. To estimate movement into or out of the canal, a stop net was placed across the mouth of the canal. This series of nets collected all fish entering or exiting the canal. The nets were set up weekly, for 24 hours, during times of red drum abundance, and were emptied every three hours. Monthly summaries of red drum movements through the canal are shown in Table 9. Greatest movement occurred during winter at times of greatest population size as well as during periods of coldest water temperature and lowest tides of the year. No evidence suggests that the canal population resides in the canal for a short period of time and then moves out. Apparently, the majority of the fish remain in the canal. This is supported by the length of time marked fish remained in the canal (Table 10). These data suggest that small juveniles that enter the canal remain at least through the spring, by which time the majority have died. Fish marked throughout the fall and winter were found in the canal in the spring (in greatly reduced numbers). Mortality estimates were made with the assumptions that no immigration or emigration occurred after the point of highest standing crop was reached, and that the decay in standing crop was a function of mortality.

Mortality was then calculated as the percentage change in monthly standing crop estimates. An overall estimated monthly mortality rate of approximately 35% was calculated. Expanding this rate through to the spring would yield similar numbers to the low numbers of fish seen in the canal. By May the remaining fish are about 180 mm standard length. It is possible that these fish move into the bay at this time. However, samplings during the summer occasionally collected red drum. These larger fish probably are not as vulnerable to the seine so interpretation of collections must be guarded.

During this next year, juvenile red drum obtained either from the DNR hatchery or collected from another site in the Alafia River will be marked and released throughout the canal. Growth, mortality, migration, and net production will then be monitored to estimate the influence of augmentation on the natural standing crop.

## TASK 5: PUBLIC EDUCATION AND INFORMATION ON COASTAL WETLANDS AND REEFS

Efforts of Task 5 focused on the production and distribution of educational brochures that describe Florida seagrasses, mangroves, saltmarsh, estuaries, and coral reefs (see Brochure Pocket in back of this report). These brochures stress the importance of estuarine environments as fisheries habitat. The coral reef brochure was created in 1986; 40,000 were reprinted with this year's money at a total cost of \$2,305.00. The others were created in 1984 and were reprinted on demand. This year, 55,000 of each brochure were reprinted at a total cost of \$7,591.00. The new brochures will include a statement that gives credit to the DER Office of Coastal Management and NOAA for making possible the creation and printing of the brochures.

Pinellas Suncoast Tourism Promotion, Inc. was contracted to distribute 15,000 of each brochure to 200 locations along Florida's west coast (Table 11). The brochures were placed into literature racks within lobbies or similar central locations of motels, restaurants, car rental offices, banks, and more. The racks were refilled monthly by the company.

Numerous requests for this type of information were received throughout the year. Organizations accounted for about 50% of the requests (Table 12); the remainder were individuals. The approximate number of brochures distributed from January through September, 1987 is as follows:

Estuaries: 12,537

Mangroves: 12,909

Seagrasses: 12,721

Salt marsh: 12,839

Coral Reef: 9,786

These numbers do not reflect the additional 15,000 distributed by Pinellas

Suncoast Tourism Promotion, Inc., those distributed by laboratory personnel during presentations, nor those taken from our Laboratory reception area. The brochures continue to be in great demand, and public response concerning their appearance and content assures us of their success and value.

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Table A. Oxygen flux rates measured in situ during September 1987. P/R denotes the ratio of 12 hrs GPP/24 hrs RESP.

SITE/CHAMBER	FLUX RATE ( g O <sub>2</sub> m <sup>-2</sup> h <sup>-1</sup> )			
	NET PHOTO- SYNTHESIS	RESPIRATION	GROSS PRIMARY PRODUCTION	P/R
A. SEWAGE				
1	0.62	-0.14	0.76	2.7
2	0.42	-0.20	0.62	1.6
3	0.24	-0.25	0.49	0.98
4	0.43	-0.24	0.67	1.4
x(s)	0.43(0.15)	-0.21(0.05)	0.63(0.11)	1.7(0.7)
B. STRESS				
1	0.37	-0.26	0.65	1.2
2	0.41	-0.36	0.77	1.1
3	0.33	-0.32	0.65	1.0
4	0.18	-0.27	0.45	0.83
x(s)	0.33(0.10)	-0.30(0.046)	0.63(0.13)	1.0(0.16)
C. CONTROL				
1	0.36	-0.23	0.59	1.3
2	0.28	-0.31	0.59	0.95
3	0.26	-0.25	0.51	1.0
4	0.052	-0.17	0.22	0.66
x(s)	0.24(0.13)	-0.24(0.058)	0.48(0.17)	0.98(0.26)

Table B: Structural characteristics of Thalassia testudium at three sites used for community metabolism measurements.

SITE	BLADE CHARACTERISTICS								
	BIOMASS		SHOOT DENSITY	BLADES PER SHOOT	MAXIMUM BLADE LENGTH	MEAN BLADE LENGTH	BLADE WIDTH	GREEN LEAF AREA	EPIPHYTE LEAF AREA
	SHOOT (g m <sup>-2</sup> )	ROOTS (g m <sup>-2</sup> )	(m <sup>-2</sup> )	(NO)	(mm)	(mm)	(mm)	(%)	(%)
CONTROL									
mean	144	211	298	2.8	378	228	9.4	77.1	22.9
std.		(63)	(38.5)	(0.6)	(96.4)	(126)	(1.1)	(27.1)	(30.2)
n	4	4	4	50	50	54	20	70	75
STRESS									
mean	129	177	341	3.0	406	304	8.1	65.1	11.6
std.	(41)	(30)	(45.5)	(0.8)	(157)	(175)	(1.1)	(26.1)	(20.9)
n	4	4	4	50	47	74	20	70	78
SEWAGE									
mean	96.0	61.4	254	3.1	382	274	6.7	43.8	33.2
std.	(42)	(18)	(45.5)	(0.9)	(105)	(146)	(1.1)	(23.4)	(33.6)
n	4	4	4	50	48	69	20	75	77

Table C. Comparison of flux rates measured in chambers with total flux rates obtained by summing component fluxes measured in BOD bottles. Units are  $\text{g O}_2 \text{ m}^{-2} \text{ h}^{-1}$ .

	SEWAGE	STRESS	CONTROL
A. RESPIRATION (DARK FLUXES)			
SEDIMENT BOD	-0.26	-0.24	-0.23
SEDIMENT COD*	-3.86	-3.11	-2.73
THALASSIA (ABOVE GROUND)	-0.12	-0.18	-0.19
WATER	<u>-0.071</u>	<u>-0.016</u>	<u>-0.095</u>
COMPONENT SUM	-0.45	-0.44	-0.51
CHAMBER ESTIMATE	-0.21	-0.30	-0.24
B. NET PHOTOSYNTHESIS (LIGHT FLUXES)			
THALASSIA (ABOVE GROUND)	1.21	0.93	0.96
WATER	<u>0.22</u>	<u>0.099</u>	<u>0.039</u>
COMPONENT SUM	1.43	1.03	1.00
CHAMBER ESTIMATE	0.43	0.33	0.24
C. BALANCE (UNITS ARE NET $\text{G O}_2 \text{ M}^{-2} \text{ DAY}^{-1}$ )			
COMPONENT SUM	+11.7	+7.08	+5.88
CHAMBER ESTIMATE	+2.64	+0.36	+0.00

\* not used in sums or balance calculation, see text

Table D: Regression models of the interaction of sulfide concentrations and Thalassia growth in laboratory experiments. TOTLTH=Total blade length per pot, SULFIDE=pore water sulfide concentration in micromoles per liter, BLADELOG=  $\log_{10}$  TOTLTH, MEANGROWTH= mean blade elongation rate by pot, SUMGROWTH= total length of new blades produced, and TURNOVER= TOTLTH/SUMGROWTH.

A. COMPARISONS OF THALASSIA STANDING CROP WITH PORE WATER SULFIDE

<u>Model</u>	<u>Expt.</u>	<u>Date</u>	<u>Dependent Variable</u>	<u>Independent Variable(s)</u>	<u>Estimates</u>	<u>F-Value</u>	<u>PR <math>\geq</math> F</u>	<u>R<sup>2</sup></u>
1.	1	6/20	TOTLTH	INTERCEPT SULFIDE	2710 -0.25	2.65	0.11	0.06
2.	2	8/3	TOTLTH	INTERCEPT SULFIDE	2132 -0.40	5.98	0.02	0.12
3.	2	8/3	SULFIDE	INTERCEPT SULFIDE	1160 -0.30	5.98	0.02	0.12
4.	2	8/3	SULFIDE	INTERCEPT BLADELOG	3794 -987	6.92	0.01	0.14
5.	3	10/14	SULFIDE	INTERCEPT TOTLTH	2320 -0.42	3.11	0.09	0.07

Table D (continued):

## B. COMPARISON OF GROWTH RATES WITH SULFIDE CONCENTRATIONS

6.	2	8/15	MEANGROWTH	INTERCEPT SULFIDE	8.81 -0.001	2.11	0.15	0.05
7.	2	8/15	MEANGROWTH	INTERCEPT SUMLENGTH1 SULFIDE	8.38 0.00021 0.00139	1.06	0.36	0.05
8.	2	8/15	SUMGROWTH	INTERCEPT SULFIDE	163.3 -0.03	3.85	0.06	0.08
9.	2	8/15	SUMGROWTH	INTERCEPT SULFIDE	62.5 -0.021	6.83	0.003	0.24
10.	2	8/3	TURNOVER	INTERCEPT SULFIDE	113.1 -0.021	0.21	0.65	0.004
11.	3	10/14	MEANGROWTH	INTERCEPT SULFIDE	14.37 -1.54	2.37	0.13	0.05
12.	3	10/14	MEANGROWTH	INTERCEPT SULFIDE SL1	6.59 0.00056 0.0000048	1.16	0.32	0.05
13.	3	10/14	SUMGROWTH	INTERCEPT SULFIDE	121 -0.017	5.73	0.02	0.12
14.	3	10/14	SUMGROWTH	INTERCEPT SULFIDE SL1	30.27 -0.0064 0.045	25.6	0.001	0.54
15.	3	10/14	TURNOVER	INTERCEPT SULFIDE	141.3 0.013	1.93	0.17	0.04

Table E: Responses of sediment sulfide concentrations and Thalassia turnover times to experimental manipulation.

- a. Percent change in pot interstitial sulfide concentrations in response to experimental manipulation. Standard deviations are in parentheses. N=4 for each cell.

GROUP	TREATMENT			
	CONTROL	AERATED	LACTATE	SHADE
HIGH SULFIDE	-11% (22)	-61% (13)	+70% (1)	-44% (25)
MEDIUM SULFIDE	-11% (51)	-59% (52)	+25% (50)	-63% (26)
LOW SULFIDE	+16% (81)	+25% (1)	-43% (-)	-63% (26)

- b. Turnover numbers of leaf biomass in response to experimental manipulation. Higher numbers represent slower growth, while lower numbers indicate more rapid growth. Standard deviations are in parentheses. N=4 for each cell.

GROUP	TREATMENT			
	CONTROL	AERATED	LACTATE	SHADE
HIGH SULFIDE	14.9 (5.5)	11.2 (3.2)	37.4 (50.9)	10.7 (8.3)
MEDIUM SULFIDE	11.8 (6.5)	10.4 (3.2)	8.7 (2.4)	11.9 (8.4)
LOW SULFIDE	10.7 (3.2)	14.6 (8.4)	8.8 (-)	8.5 (2.3)

Table 1. Summary of data requests

1. Florida State University, Economics Dept.; wetland acreages for Florida west coast
2. U.C.L.A., California; habitat maps of Charlotte Harbor
3. Citrus County; marine wetland maps
4. Tampa Tribune; habitat loss for Tampa Bay with slides
5. DNR, Marathon; habitat acreages for the Keys
6. Fl. GFWFC; grass bed analysis off Steinhatchee River
7. Fl. GFWFC; evaluation of a LANDSAT feasibility study
8. Fl. GFWFC; memorandum of understanding for LANDSAT non-game wildlife habitat assessment cooperative exchange
9. Olson and Associates, Jacksonville
10. Governors Office of the Auditor General; map of Tampa Bay habitat loss.
11. U.S. Dept. of Education; Tampa Bay Habitat Maps
12. DER, OFW program; slides of Indian River Lagoon
13. Pinellas County Planning Dept.; habitat maps of Pinellas County
14. Alvarez, Lehman and Assoc., Gainesville; fisheries habitat of northeast Fl.
15. U.S.F.W.S., Jacksonville; seagrass maps of Indian River Lagoon
16. Pinellas Planning Council; habitat maps
17. City of Jacksonville; fisheries habitat maps and report
18. Fla. State University, Library; reprints and Charlotte Harbor Report
19. Florida State Museum; habitat maps and report for Charlotte Harbor
20. West Palm Beach Planning Dept.; Lake Worth habitat maps
21. Cooperative Fish and Wildlife Research Unit; Landsat data for Miami area
22. South Florida Water Management District; MRGIS data for Okeechobee
23. St. Johns Water Management District; ELAS software modules
24. Trust for Public Lands; images of Garcon Pt. in Pensacola area
25. Ducks Unlimited; ELAS software modules
26. University of Texas; ELAS documentation
27. Mote Marine Laboratory; MRGIS slides
28. Florida Marine Fisheries Commission; MRGIS slides
29. EOSAT Corp.
30. NASA
31. EPA Region IV; entire slide set of west Florida estuaries, about 100 slides
32. South West Florida Water Management District; MRGIS slides
33. Mangrove Systems Inc.; MRGIS slides
34. DSA Group, Inc.; habitat maps of Tampa Bay
35. Bradenton Herald; habitat inventory and trends for Perico Island
36. Mark Weitz, Outdoor Writer; bait shrimping and seagrass loss slides and maps
37. Palm Beach, City Planning Dept.; Lake Worth habitat maps
38. NOAA, SE Fisheries Center; estimate of Florida east coast acreages of estuarine water for a pink shrimp analysis
39. Tampa Bay RPC; habitat maps for Tampa Bay
40. All Release Sports Society; habitat maps of Little Manatee River
41. Hillsborough County, Planning Dept.; habitat maps and acreage analyses for Hillsborough County
42. Dauphin Island Marine Lab; grass bed inventory of northwest Florida

Table 1 (continued).

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43. Pinellas County Planning Dept.; habitat maps
  44. Greiner Engineering; resource analysis for new Howard Franklin Bridge construction
  45. University of Georgia; NE Florida Report and maps of Nassau County
  46. Fl. GFWFC; maps for bear corridor analyses of Wekiva River area
  47. West Florida Regional Planning Council; habitat maps for their district
  48. Barret, Daffin and Carlan, Inc., Alabama; habitat maps for Walton and Okaloosa Counties
  49. City of Dunedin; habitat maps
  50. Collier County; habitat maps
  51. Hernando County; habitat maps
  52. DCA; habitat maps for Pensacola Bay
  53. Fl. Institute of Technology; habitat maps for Dade, Sarasota, Monroe, Jacksonville (Duval), and Broward Counties
  54. Levy County; habitat maps
  55. West Palm Beach; habitat maps
  56. Alvarez, Lehman & Assoc., Gainesville; habitat maps for St. Johns County
  57. Univ. of Georgia; habitat maps for Pensacola and Ft. Myers

Table 2. Presentations concerning the MRGIS by Ken Haddad.

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1. American Society of Photogrammetry and Remote Sensing, Florida Chapter.
  2. Seventh Annual Minerals Management Service Gulf of Mexico Information Transfer Meeting.
  3. Manasota Chapter of the American Society of Land Surveyors.
  4. Coastal Zone 87.
  5. Marine Resource Council of East Central Florida Annual Meeting.
  6. Florida Editorial Writers Conference.
  7. Mote Marine Laboratory.
  8. South West Florida Watermanagement District SWIM Conference.

Table 3. Density and diversity estimates of organisms captured off Tarpon Key, FL. CV = coefficient of variation.

Gear type	Number of Samples	<u>Density</u>	<u>CV</u>	<u>Diversity</u>	<u>CV</u>
		mean number organisms/m <sup>2</sup> + SD	100( $\bar{x}/SD$ )	mean number species/m <sup>2</sup> + SD	100( $\bar{x}/SD$ )
1m <sup>2</sup> Tripod Drop Net	15	4.60 + 4.0	86.1%	2.93 + 1.6	53.9%
2m <sup>2</sup> Tripod Drop Net	15	6.07 + 3.8	63.1%	3.33 + 1.9	57.2%
4m <sup>2</sup> Tripod Drop Net	16	6.20 + 3.9	63.2%	3.41 + 2.6	75.8%
1m <sup>2</sup> Boom Drop Net	36	6.36 + 5.1	80.4%	2.42 + 0.8	34.8%
6.1m Otter Trawl	(100m)13	1.08 + 0.64	60.0%	0.03 + 0.01	34.1%
	( 50m)18	0.99 + 0.54	54.5%	0.04 + 0.01	27.9%
Roller Shrimp Trawl	36	0.42 + 0.30	70.8%	0.03 + 0.01	33.1%

Table 4. List of species captured by each gear type, OT = otter trawl, RT = roller trawl.

Species List	Method of Capture					OT	RT
	1m <sup>2</sup>	Tripod 2m <sup>2</sup>	4m <sup>2</sup>	Boom 1m <sup>2</sup>			
<u>Brevoortia sp.</u>						X	
<u>Harengula jaguana</u>			X			X	
<u>Arius felis</u>						X	
* <u>Opsanus beta</u>	X	X	X	X		X	X
* <u>Floridichthys carpio</u>	X	X	X	X		X	X
* <u>Lucania parva</u>	X	X	X	X		X	X
<u>Menidia berylina</u>		X	X			X	X
<u>Hippocampus zosterae</u>				X		X	X
* <u>Sygnathus scovelli</u>	X	X	X	X		X	X
<u>Sygnathus louisianae</u>						X	
<u>Centropristis striata</u>						X	
<u>Mycteroperca microlepis</u>						X	
<u>Lutjanus griseus</u>			X	X		X	X
* <u>Eucinostomus sp.</u>	X	X	X	X		X	X
<u>Orthopristis chrysoptera</u>		X	X	X		X	X
<u>Arthosargus probatocephalus</u>				X		X	X
* <u>Lagodon rhomboides</u>	X	X	X	X		X	X
<u>Bairdiella chrysoura</u>			X			X	X
<u>Cynoscion nebulosus</u>						X	X
<u>Leiostomus xanthurus</u>						X	
<u>Chasmodes sabusiae</u>		X	X			X	X
<u>Gobisoma robustum</u>	X	X	X	X		X	
* <u>Microgobius gulosus</u>	X	X	X	X		X	X
<u>Paralichthys albigutta</u>						X	
<u>Achirus lineatus</u>						X	
<u>Chilomycterus scholpfi</u>						X	X
<u>Sympurus plagusa</u>	X						
<u>Callinectes sapidus</u>			X	X		X	X
<u>Penaeus duorarum</u>	X	X	X	X		X	X

\*Fish species captured by all gear types.

Table 5. Greatest percentage of organisms captured by each gear type.

Gear Type	Day and night sampling		Data excluding night sampling	
	(% of organism comprising sample)		(% of organism comprising sample)	
Roller	<u>L. parva</u>	50.5	<u>L. parva</u>	64.6
Trawl	<u>Eucinostomus sp.</u>	16.8	<u>Eucinostomus sp.</u>	21.5
	<u>P. duorarum</u>	16.4	<u>P. duorarum</u>	0.4
Otter	<u>L. parva</u>	41.6	<u>L. parva</u>	44.8
Trawl	<u>L. rhomboides</u>	38.3	<u>L. rhomboides</u>	36.2
	<u>Eucinostomus sp.</u>	7.6	<u>Eucinostomus sp.</u>	7.5
	<u>P. duorarum</u>	1.7	<u>P. duorarum</u>	0.3
Boom	<u>L. parva</u>	64.5	<u>L. parva</u>	65.7
Drop	<u>Eucinostomus sp.</u>	6.1	<u>Eucinostomus sp.</u>	5.1
	<u>P. duorarum</u>	8.2	<u>P. duorarum</u>	7.1
1m <sup>2</sup>	<u>L. parva</u>	63.8	<u>L. parva</u>	64.6
Drop	<u>G. robustum</u>	11.6	<u>G. robustum</u>	12.3
Net	<u>M. gulosus</u>	5.8	<u>M. gulosus</u>	6.2
	<u>P. duorarum</u>	2.9	<u>P. duorarum</u>	0.0
2m <sup>2</sup>	<u>L. parva</u>	49.5	<u>L. parva</u>	51.2
Drop	<u>M. berylina</u>	9.9	<u>M. berylina</u>	10.6
Net	<u>L. rhomboides</u>	8.8	<u>L. rhomboides</u>	8.8
	<u>P. duorarum</u>	6.6	<u>P. duorarum</u>	4.7
4m <sup>2</sup>	<u>L. parva</u>	68.8	<u>L. parva</u>	70.9
Drop	<u>L. rhomboides</u>	7.3	<u>L. rhomboides</u>	7.0
Net	<u>P. duorarum</u>	7.3	<u>P. duorarum</u>	5.4

Table 6. Density and percentage of total drop net catch estimated for G. robustum and M. gulosus.

	# different species captured	<u>G. robustum</u>		<u>M. gulosus</u>	
		as % total catch	density	as % total catch	density
1m <sup>2</sup>	9	11.6	.53/m <sup>2</sup>	5.8	.27/m <sup>2</sup>
2m <sup>2</sup>	11	6.6	.40/m <sup>2</sup>	5.5	.33/m <sup>2</sup>
4m <sup>2</sup>	14	2.8	.17/m <sup>2</sup>	2.5	.16/m <sup>2</sup>

Table 7. Average density (fish/1000m<sup>2</sup>) for the seven fish species common to all gear types. OT = otter trawl, RT = roller trawl.

Species	Gear Type					
	Tripod			Boom 1m <sup>2</sup>	OT	RT
	1m <sup>2</sup>	2m <sup>2</sup>	4m <sup>2</sup>			
<u>O. beta</u>	130	300	230	310	20	3
<u>L. parva</u>	2,930	3,000	4,270	4,140	430	210
<u>S. scovelli</u>	70	30	20	30	10	8
<u>Eucinostomus sp.</u>	200	200	140	390	80	72
<u>L. rhomboides</u>	130	530	450	170	400	39
<u>M. gulosus</u>	270	330	160	170	1	0.7
<u>F. carpio</u>	130	100	110	360	30	8

Table 8. Average standard length (mm) for six fish species captured with all gear types. Number in parenthesis indicates total number of this species captured with each gear. OT = otter trawl, RT = roller trawl.

Species	Tripod			Boom 1m <sup>2</sup>	OT	RT
	1m <sup>2</sup>	2m <sup>2</sup>	4m <sup>2</sup>			
<u>O. beta</u>	57.5(2)	57.4(9)	54.6(15)	52.2(11)	85.7(143)	85.5(17)
<u>L. parva</u>	21.5(45)	22.6(79)	22.8(220)	22.3(148)	24.8(507)	25.7(556)
<u>S. scovelli</u>	95.0(1)	105.0(1)	106.0(1)	120.0(1)	111.8(93)	109.9(44)
<u>Eucinostomus sp.</u>	24.3(3)	28.5(6)	26.8(9)	27.0(12)	37.3(219)	30.1(311)
<u>L. rhomboides</u>	62.5(2)	74.1(16)	69.7(29)	85.8(6)	79.5(604)	77.9(152)
<u>M. gulosus</u>	22.3(4)	21.9(10)	23.9(10)	27.7(6)	23.4(9)	31.0(4)

Table 9. Maximum residency times of red drum in the Alafia River canal study site for each marking experiment during 1986-87.

Color Marked	Date Released	Date last collected	No. of days in canal
Light Green	27 Oct 86	7 April 87	162
Orange	10 Nov 86	21 April 87	162
Red	25 Nov 86	28 April 87	154
Dk Grn/Red	12 Jan 87	12 May 87	120
Dark Green	2 Feb 87	25 March 87	51
Red/Orange	24 Feb 87	5 May 87	70
Dk Grn/Orange	24 March 87	21 April 87	28

Table 10. Summary of red drum collected in the stop net from the Alafia River study site. Average soak time per haul is about three hours.

Date	No. of Hauls	No. Incoming	Fish/Haul Incoming	No. Outgoing	Fish/Haul Outgoing
11/85	14	2	0.14	4	0.29
12/85	30	18	0.60	11	0.37
1/86	36	145	4.03	353	9.81
2/86	30	27	0.90	5	0.17
3/86	14	12	0.86	3	0.21
4/86	7	0	0	0	0
5/86	0	-	-	-	-
6/86	0	-	-	-	-
7/86	16	0	0	0	0
8/86	51	1	0.02	0	0
9/86	58	3	0.05	0	0
10/86	51	5	0.10	4	0.08
11/86	39	9	0.23	5	0.13
12/86	40	49	1.23	10	0.25
1/87	30	103	3.43	43	1.43
2/87	27	368	13.63	84	3.11
3/87	30	18	0.60	6	0.20
4/87	27	6	0.22	14	0.52
5/87	14	6	0.43	3	0.21
6/87	0	-	-	-	-
7/87	0	-	-	-	-
8/87	0	-	-	-	-

Table 11. Distribution locations of CZM brochures.

AAA Motor Club (OR)	2170 Rainbow Dr.	CLEARWATER
AAA Motor Club (OR)	4800 US 19 No.	Palm Harbor
AAA Motor Club (OR)	9200 Seminole Blvd.	Seminole
AAA Motor Club (OR)	1211 1st. Ave.No.	St. Petersburg
Aaegean Sands Resort	421 S. Gulfview Blvd.	Clearwater
Adam's Mark	430 S. Gulfview Blvd.	Clearwater Beach
Albatross Motel	346 Hamden Dr.	Clearwater Beach,
A+ Rent-A-Car	3800 34th. St. N.	St. Petersburg
Arie Dam Resort	14600 Gulf Blvd.	Maderia Beach
Avalon Travel Trailer Park	1960 U.S. 19 S.	Clearwater
Bali Hai Suncoast Motel	350 Hamden Dr.	Clearwater Beach
Bali Hai Gulfview Motel	353 Coronado Dr.	Clearwater Beach
Bay Lawn Motel	406 Hamdin Dr.	Clearwater Beach
Bay-N-Gulf Resort	5195 Gulf Blvd.	St. Petersburg Beach
Bayway Motor Lodge	3501 34th. Av. S.	St. Petersburg
Beachcomber Resort	6200 Gulf Blvd.	St. Petersburg Beach
Beach House Motel East	12035 Gulf Blvd.	Treasure Island
Beach Moorings	620 Bayway Blvd.	Clearwater Beach
Beach Park Motel	300 Beach Dr. N.E.	St. Petersburg
Bel Crest Beach Condo Motel	706 Bayway Blvd.	Clearwater Beach
Bestwestern Gulfview Inn	504 S. Gulfview Blvd.	Clearwater Beach
Best Western Sea Wake Inn	691 S. Gulfview Blvd.	Clearwater Beach
Bilmar Beach Resort (OR)	10650 Gulf Blvd.	Treasure Island
Boatyard Village-Michaels	16100 Fairchild Dr.	Clearwater
Bon-Aire Resort Hotel	4350 Gulf Blvd.	St. Petersburg Beach
Bond Motel	421 4th. Av. N.	St. Petersburg
Breckenridge Resort Hotel	5600 Gulf Blvd.	St. Petersburg Beach
Budget Rent-A-Car	5400 Gulf Blvd	St. Petersburg Beach
Cadillac On The Gulf	3828 Gulf Blvd.	St. Petersburg Beach
Camelot By The Sea	1801 Gulf Way	St. Petersburg Beach
Camelot Motel	603 Mandalay Ave.	Clearwater Beach
Clearwater Beach Resort	678 S. Gulfview Blvd.	Clearwater Beach
Clearwater Beach Hotel	500 Mandalay Ave.	Clearwater Beach
Coca Cabana Motel	669 Mandalay Ave.	Clearwater Beach
Country Dinner Playhouse	7951 Gateway Mall	St. Petersburg
COLONIAL HOTEL	126 2nd. Ave. N.E.	St. Petersburg
COMFORT INN	3580 Ulmerton Rd.	Clearwater
COMMODORE BEACH CLUB	13536 Gulf Blvd.	Maderia Beach
DOLPHIN BEACH RESORT	4900 Gulf Blvd.	St. Petersburg Beach
DOLPHIN MOTEL	1359 34th. St. N.	St. Petersburg
DON CE SAR RESORT (OR)	3400 Gulf Blvd.	St. Petersburg Beach
ECHO SAILS MOTEL	216 hamden Dr.	Clearwater Beach
ECONOLOGDE (OR)	4770 US ( No.	Palm Harbor
EL SIRATA MOTEL	5390 Gulf Blvd.	St. Petersburg Beach
EXECUTIVE MOTOR LODGE	3080 34th. St. N.	St. Petersburg
FALCON MOTEL	415 Coronado Dr.	Clearwater Beach
FLAMINGO MOTEL (OR)	450 N. Gulf view Blvd.	Clearwater Beach
FLORIDA NATIONAL BANK	3805 Gulf Blvd.	St. Petersburg Beach
GATEWAY MOTEL	4990 34th. St. N.	St. Petersburg
GLASS HOUSE MOTEL	229 Gulfview Blvd	Clearwater Beach
GULF BEACH MOTEL	419 Coronado Dr.	Clearwater Beach
GULF GARDENS	14141 Gulf Blvd.	Maderia Beach
GULF SANDS BEACH RESORT	655 S. Gulfview Blvd.	Clearwater Beach

Table 11 (continued).

HAMLINS LANDING	401 2nd. St. E.	Indian Rocks
HILTON INN	715 S. Gulfview Blvd.	Clearwater Beach
HILTON INN	5250 Gulf Blvd.	St. Petersburg Beach
HI SEAS MOTEL	455 S. Gulfview Blvd.	Clearwater Beach
HOLIDAY HOUSE MOTEL	495 N. Gulfview Blvd.	Clearwater Beach
HOLIDAY INN CLEARWATER CENT.	400 US19 So.	Clearwater
HOLIDAY INN GULFVIEW	521 S. Gulfview Blvd.	Clearwater Beach
HOLIDAY INN I-275	3000 34th. St. S.	St. Petersburg
HOLIDAY INN MADERIA BEACH	15208 Gulf Blvd.	Maderia Beach
HOLIDAY INN SOUTH	4601 34th. St. S.	St. Petersburg
HOLIDAY INN SURFSIDE	400 Mandalay Ave.	Clearwater Beach
HOLIDAY INN ST PETERSBURG BCH.	5300 Gulf Blvd.	St. Petersburg Beach
HOLIDAY INN ST. PETE CLWR.	3535 Ulmerton Rd.	Clearwater
HOLIDAY INN TREASURE IS.	11908 Gulf Blvd.	Treasure Island
HOLIDAY ISLE MOTEL	14711 Gulf Blvd.	Maderia Beach
ISLANDER MOTEL	4321 Gulf Blvd.	St. Petersburg Beach
ISLAND INN SHORES	9980 Gulf Blvd.	Treasure Island
JET EXECUTIVE CENTER	1590 Fairchild Dr.	Clearwater
JOHN'S PASS-BEACH MOTEL	12600 Gulf Blvd.	Treasure Island
LAGOON RESORT MOTEL	619 S. Gulfview Blvd.	Clearwater Beach
LA MARK CHARLES MOTEL	6200 34th. St. N.	Pinellas Park
LA QUINTA MOTOR INN	7500 US 19 N.	Pinellas Park
LEHIGH CORPORATION	5005 34th. St. N.	St. Petersburg
LINDOS RENT-A-CAR	1886 US 19 So.	Clearwater
LONDON WAX MUSEUM	5505 Gulf Blvd.	St. Petersburg Beach
MADERIA VISTA	14800 Gulf Blvd.	Maderia Beach
MAGNOLIA HOTEL	444 1st. Ave. N.	St. Petersburg
MCCARTHY HOTEL	326 1st. Ave. N.	St. Petersburg
MIDTOWN MOTOR LODGE	US 19 & 5th. Ave. N.	St. Petersburg
MOLLOY GULF MOTEL	10164 Gulf Blvd.	Treasure Island
MURPHY'S MOTEL	4900 34th. St. N.	St. Petersburg
PENNSYLVANIA	4th. St. & 3rd. Ave. N.	St. Petersburg
PONCE DE LEON HOTEL	Central Ave. & Beach Dr.	St. Petersburg
PORT OF ST. PETE		St. Petersburg
PRESIDENTIAL INN	100 2nd. Ave. S.	St. Petersburg
PRINCESS MARTHA HOTEL	401 1st. Ave. N.	St. Petersburg
QUALITY INN TRAILS END (OR)	11500 Gulf Blvd.	Treasure Island
RAMADA INN	2560 US 19 N.	Clearwater
RAMADA INN	10))) Gulf Blvd.	Treasure Island
REDINGTON SURF RESORT	17300 Gulf Blvd.	No. Redington Beach
REDINGTON AMBASSADOR	16900 Gulf Blvd.	No. Redington Beach
RESIDENCE INN	5050 Ulmerton Rd.	Clearwater
ROBBY'S PANCAKE HOUSE	10925 Gulf Blvd.	Treasure Island
ROYAL CANADIAN MOTEL	649 Mandalay Ave.	Clearwater Beach
SANDPIPER RESORT	6000 Gulf Blvd.	St. Petersburg
SANDS OF TREASURE IS. (OR)	11800 Gulf Blvd.	Treasure Island
SANDS POINT MOTEL	433 Coronado Dr.	Clearwater Beach
SATELLITE MOTEL (OR)	11205 Gulf Blvd.	St. Petersburg Beach
SEA CASTLE	10750 Gulf Blvd.	Treasure Island
SEA OATS	12625 Sunshine Lane	Treasure Island
SEA PALMS MOTEL	4999 Gulf Blvd.	St. Petersburg
SEA VIEW MOTEL	18 Bay Esplande	Clearwater Beach
SHALIMAR MOTEL	3700 Gulf Blvd.	St. Petersburg Beach

Table 11 (continued).

SHERATON SAND KEY RESORT (OR)	1160 Gulf Blvd.	Clearwater Beach
SHORELINE MOTEL	14200 Gulf Blvd.	Maderia Beach
SOUTHERN SKIES MOTEL	666 34th. St. N.	St. Petersburg
ST. PETE CHAMBER OF COM. (OR)	401 3rd. Ave. N.	St. Petersburg
SPY GLASS MOTEL	215 S. Gulfview Blvd.	Clearwater Beach
SUNCOAST REPRESENTATION SER.	150 153rd. Ave.	Maderia Beach
SUNCOAST WELCOME CENTER (OR)	2001 Ulmerton Rd.	Clearwater
SUNWOOD INN	3301 Ulmerton Rd.	Clearwater
SURF OF TREASURE ISLAND (OR)	11040 Gulf Blvd.	Treasure Island
SUPERIOR RENT-A-CAR	5905 Gulf Blvd.	St. Petersburg Beach
SUPERIOR RENT-A-CAR	Gulfview Blvd.	Clearwater Beach
SWEDEN HOUSE RESTAURANT	6300 Gulf Blvd.	St. Petersburg Beach
TAHITIAN RESORT	11300 Gulf Blvd.	Treasure Island
THUNDERBIRD RESORT MOTEL	10700 Gulf Blvd.	Treasure Island
TIERRA VERDE ISLAND RESORT	200 Madonna Blvd.	St. Petersburg Beach
TRADE WINDS MOTEL (OR)	10300 Gulf Blvd.	Treasure Island
TRADEWINDS RESORT (OR)	5400 Gulf Blvd.	St. Petersburg Beach
TREASURE SHORES BEACH CLUB	10360 Gulf Blvd.	Treasure Island
TROPIC AIRE MOTEL	35 Coronado Dr.	Clearwater Beach
TROPIC ISLE MOTEL	23 Rockaway St.	Clearwater Beach
TROPIC SHORES CONDO-MOTEL	14251 Gulf Blvd.	Maderia Beach
VALUE RENT-A-CAR	15115 Maderia Way	Maderia Beach
VALUE RENT-A-CAR	Gulf-to-Bay	Clearwater
VALUE RENT-A-CAR	Fairchild Dr.	Clearwater
VOYAGER BEACH CLUB	11860 Gulf Blvd.	Treasure Island
WELLS MANOR	333 Hamden Dr.	Clearwater Beach

#### SARASOTA LOCATIONS

AROUND THE WORLD MOTEL (OR)	129 Taft Dr.
BAYSHORE INN	3512 US 41 N.
BESTWESTERN GOLDEN HOST INN	4675 US 41
BESTWESTERN BRADENTON RESORT INN	2303 First St.
DIPLOMAT RESORT	3155 Gulf of Mexico
FOUR WINDS MOTEL	2605 Gulf of Mexico Dr.
GULF BEACH HOTEL	930 Benjamin Franklin Dr.
GULF TIDES	3000 Gulf of Mexico Dr.
HOWARD JOHNSONS RESTAURANT	US 41 - Bradenton
LIMETREE BEACH RESORT	1050 Ben Franklin Dr.
PELICAN GARDENS MOTEL	170 Roosevelt Dr.
ROYAL HEALTH & TENNIS LODGE	4229 US 41
SEA CLUB I BEACH RESORT	4141 Gulf of Mexico Dr.
SEA HORSE BEACH RESORT	3453 Gulf of Mexico Dr.
SOUTH SEAS RV RESORT	100 Palmview Rd.
SUNTIDE ISLAND BEACH CLUB	850 Ben Franklin Dr.
TWIN SHORES RESORT	3740 Gulf of Mexico Dr.
VERANDA RESORT	2509 Gulf of Mexico Dr.

Table 12. Organizations that requested and received CZM brochures.

American Boat and Yacht Council, Inc.; Amityville, NY  
 American Littoral Society; St. Petersburg, FL  
 ANERR; Apalachicola, FL  
 Apalachee Elementary School; Tallahassee, FL  
 Boy Scouts of America; St. Petersburg, FL  
 Boyd Hill Nature Trail; St. Petersburg, FL  
 Briggs Nature Center; Naples, FL  
 Camelot-by-the-Sea Resort Condominiums; Pass-a-Grill, FL  
 Campbell Drive Elementary School; Leisure City, FL  
 Cape Coral Area Chamber of Commerce, Cape Coral, FL  
 Central Jr. High School; Melbourne, FL  
 City of St. Petersburg; St. Petersburg, FL  
 Clearwater Marine Science Center; Clearwater, FL  
 Dept. of Environmental Regulation; Ft. Myers, FL  
 Dept. of Natural Resources, Bureau of Education and Information; Tallahassee  
 Dept. of Natural Resources, Division of Marine Resources; Naples, FL  
 Dept. of Natural Resources, Division of Parks and Recreation  
 Elkhorn Slough National Estuarine Research Reserve; Watsonville, CA  
 Environmental, Inc.; Tampa, FL  
 Florida Oceanographic Society; Stuart, FL  
 Florida State Museum; Gainesville, FL  
 Florida State University; Tallahassee, FL  
 Hillsborough County School System; Tampa, FL  
 Jensen Beach Chamber of Commerce; Jensen Beach, FL  
 John Pennekamp Coral Reef State Park; Key Largo, FL  
 John's Pass Sea Food Festival; Treasure Island, FL  
 Lee County School Board; Ft. Myers, FL  
 Madeira Beach Chamber of Commerce; Madeira Beach, FL  
 Marine Resources Council; Melbourne, FL  
 Miami Edison Sr. High School; Miami, FL  
 Mote Marine Laboratory; Sarasota, FL  
 Nature Conservancy  
 New Found Harbour Marine Institute; Big Pine Key, FL  
 Pinellas County School System; Clearwater, FL  
 Pinellas Marine Institute; St. Petersburg, FL  
 Pt. Charlotte Chamber of Commerce; Pt. Charlotte, FL  
 Rookery Bay; Naples, FL  
 Sarasota High School; Sarasota, FL  
 Save the Manatee Committee; Maitland, FL  
 Sea World of Florida; Orlando, FL  
 Southwest Florida Water Management District; Brooksville, FL  
 Stonewall Jackson Jr. High School; Orlando, FL  
 St. Petersburg Jr. College; St. Petersburg, FL  
 St. Petersburg Times; St. Petersburg, FL  
 Suncoast Sea Bird Sanctuary; Redington Shores, FL  
 University of So. Florida; Tampa, FL  
 University of Tampa; Tampa, FL  
 University of Florida; Gainesville, FL  
 Upper Tampa Bay Park; Oldsmar, FL

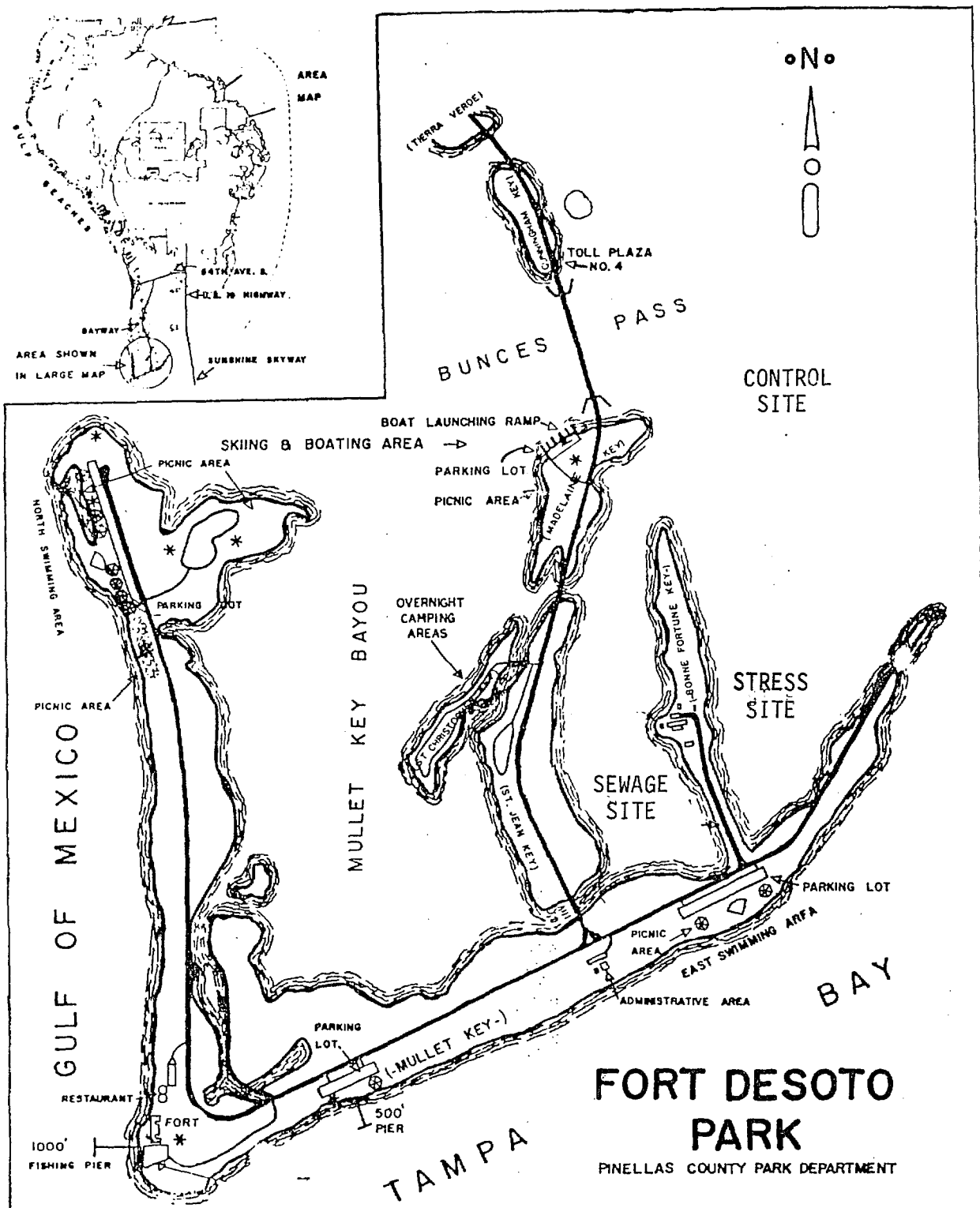


Figure A. Location of field study sites for community metabolism measurements.

# SURFACE LIGHT FLUCTUATIONS AT CONTROL SITE, 9/87

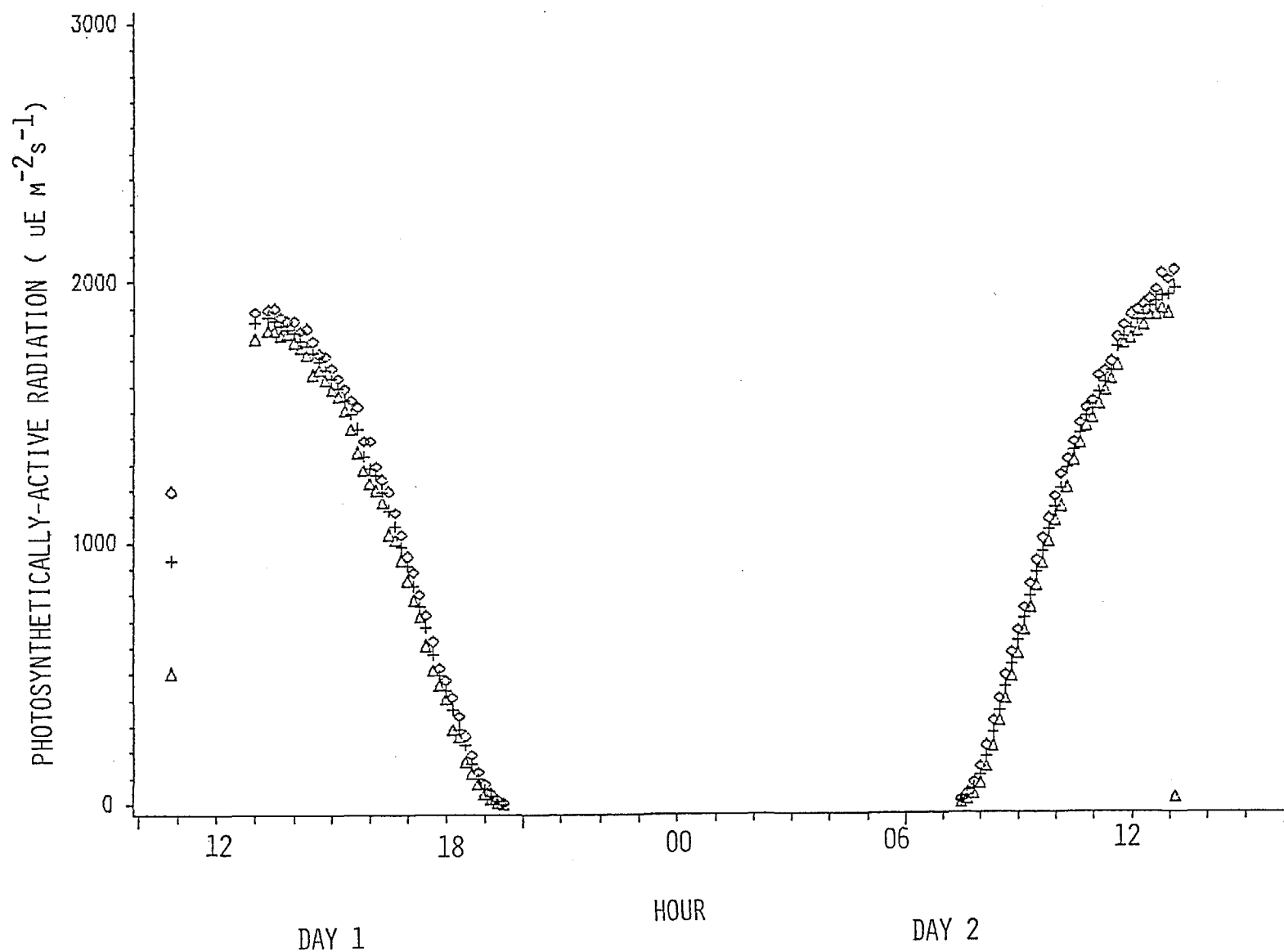


Figure B. Surface Light at Control Site, 9/87 Diel. Light values for each 10-minute logging interval are denoted by diamonds (maximum values), "+" signs (mean), and triangles (minimum values). Time is expressed as decimal hours on 24 hour clock. 00 is midnight.

# CHAMBER OXYGEN CONCENTRATIONS, CONTROL SITE, 9/87

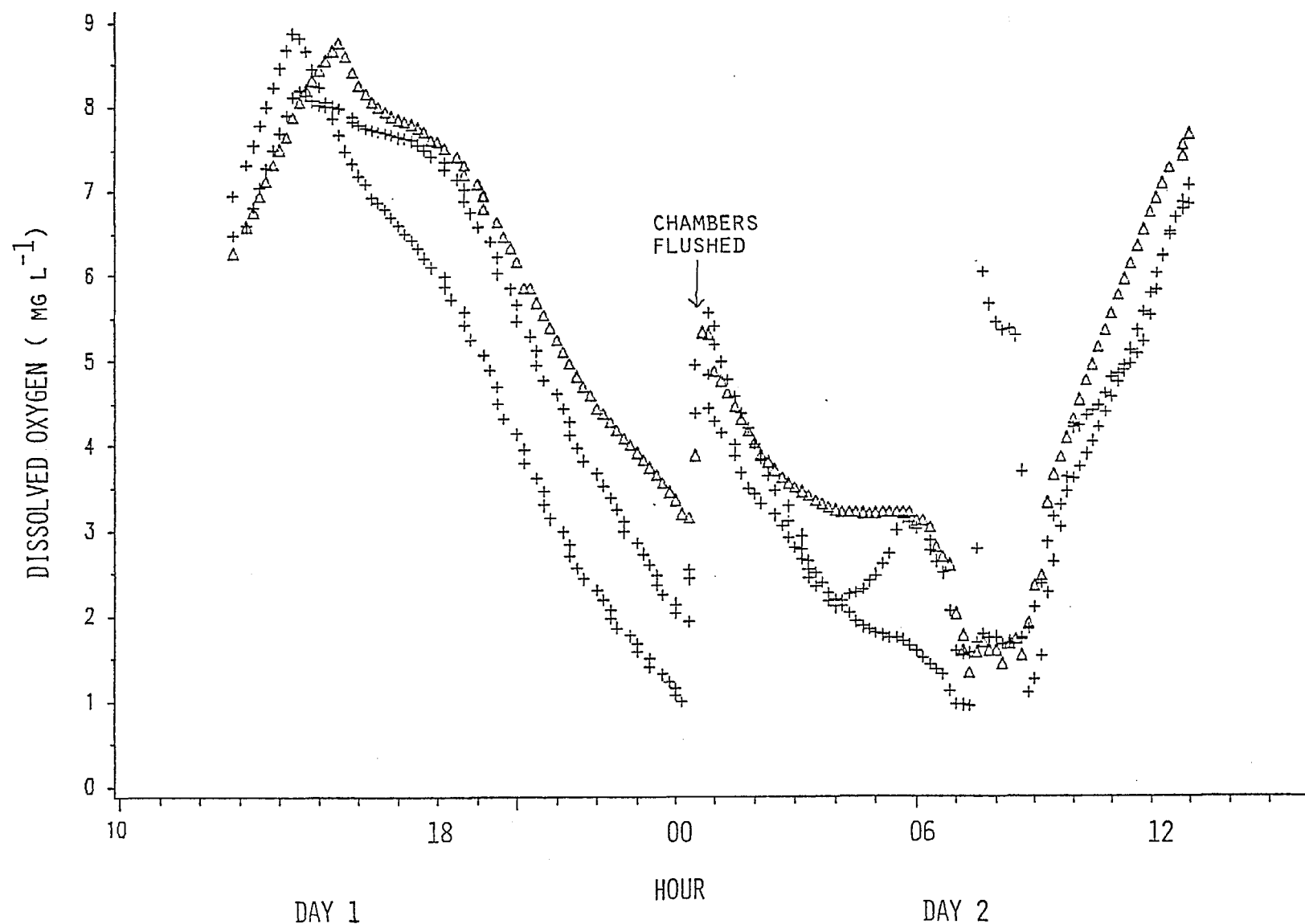


Figure C. Chamber Oxygen Concentrations, Control Site, 9/87. Four chambers are represented. Chambers flushed with outside water at 0030 h to prevent anoxia.

# DAYTIME OXYGEN FLUCTUATIONS AT CONTROL SITE, 9/87

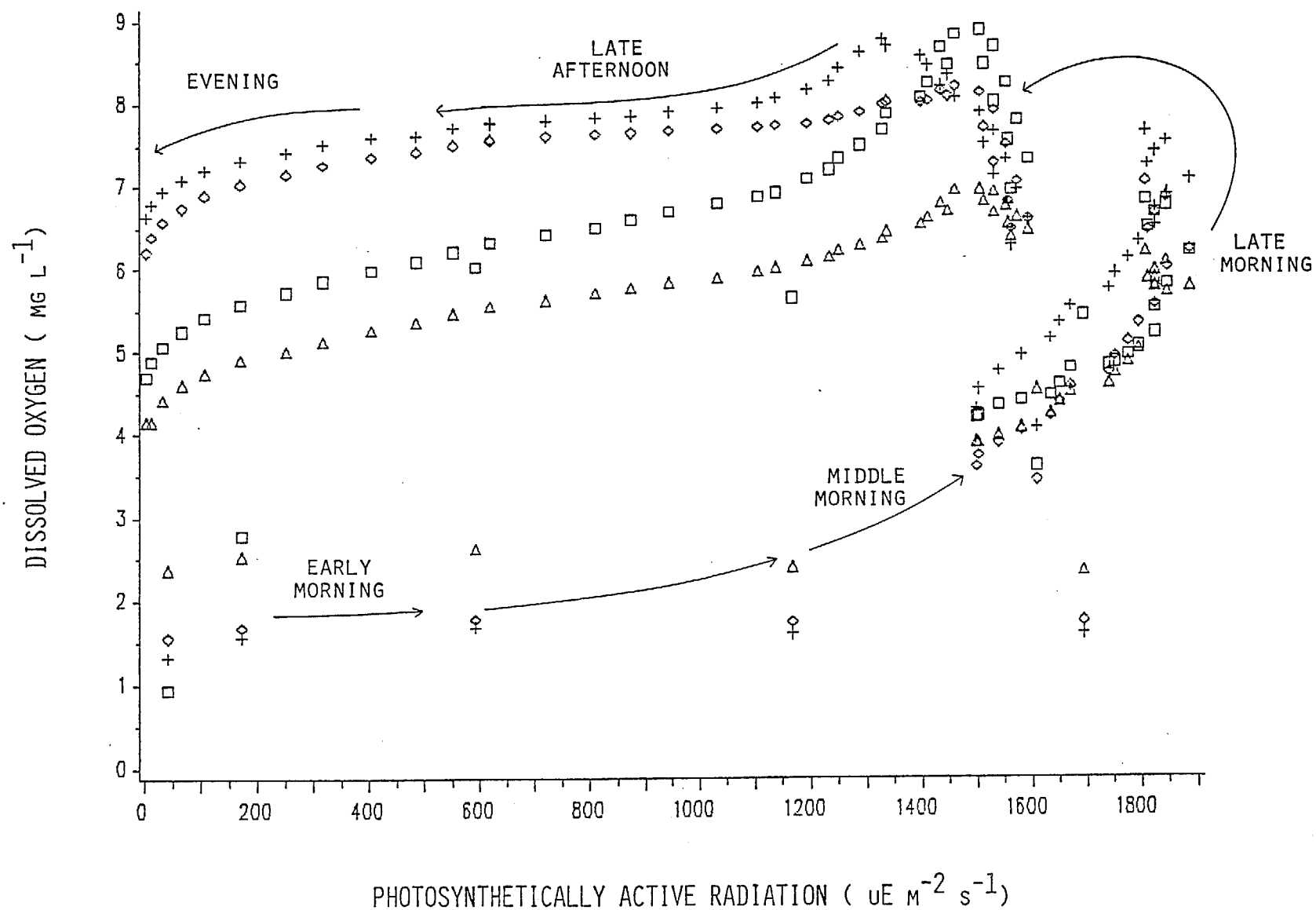


Figure D. Diurnal Cycle of Net Oxygen Productivity. Arrows identify portions of day related to each group of data.

# NIGHT-TIME OXYGEN CONSUMPTION AT CONTROL SITE, 9/87

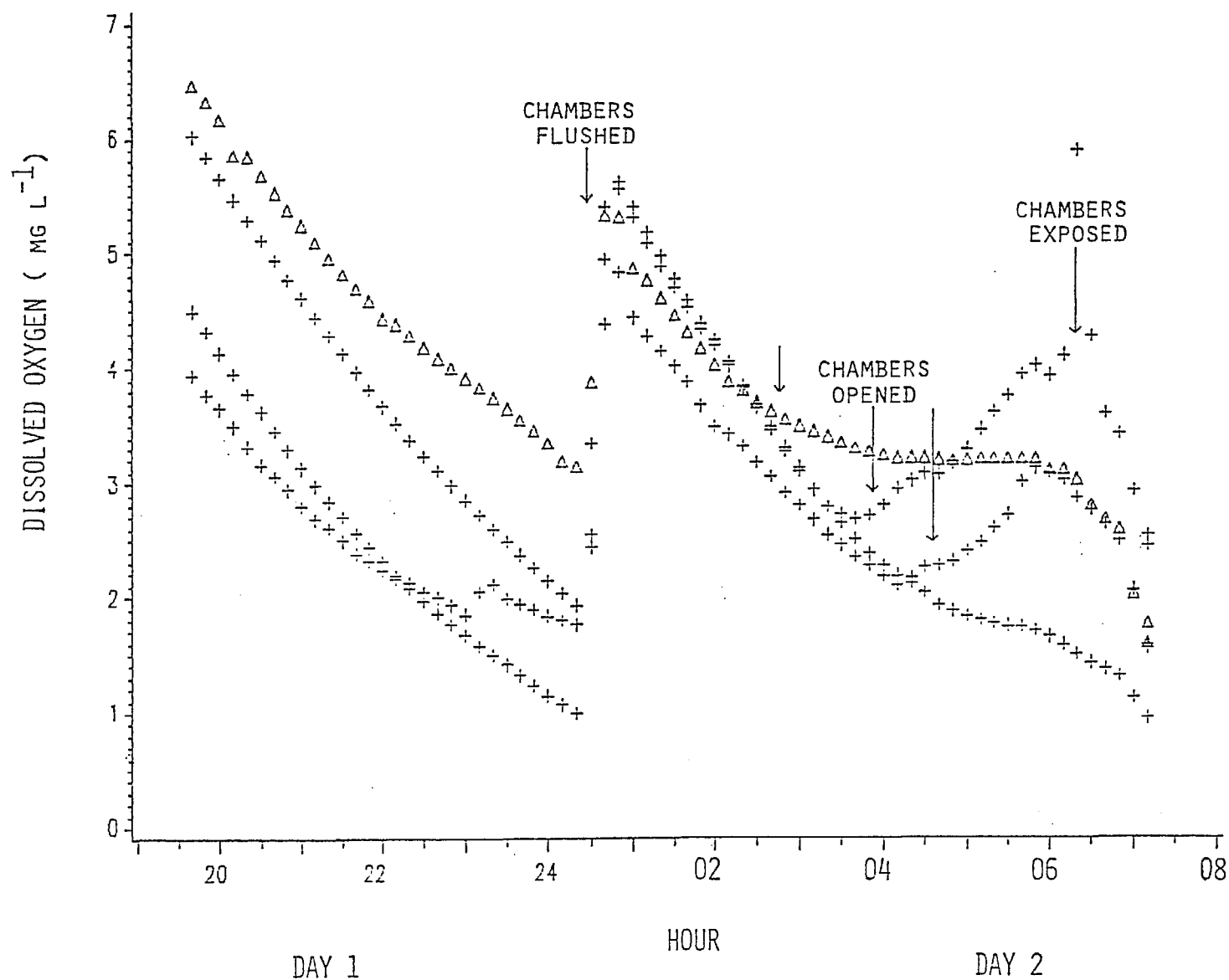


Figure E. Night-time Oxygen Consumption at Control Site, 9/87. Time expressed as decimal hours. Chambers flushed to restore oxygen concentrations to near-ambient levels 0300 h. Chambers opened completely from 0400-0600. Tidal exposure forced end of leaving 0630.

# SURFACE LIGHT FLUCTUATIONS AT STRESS SITE, 9/87

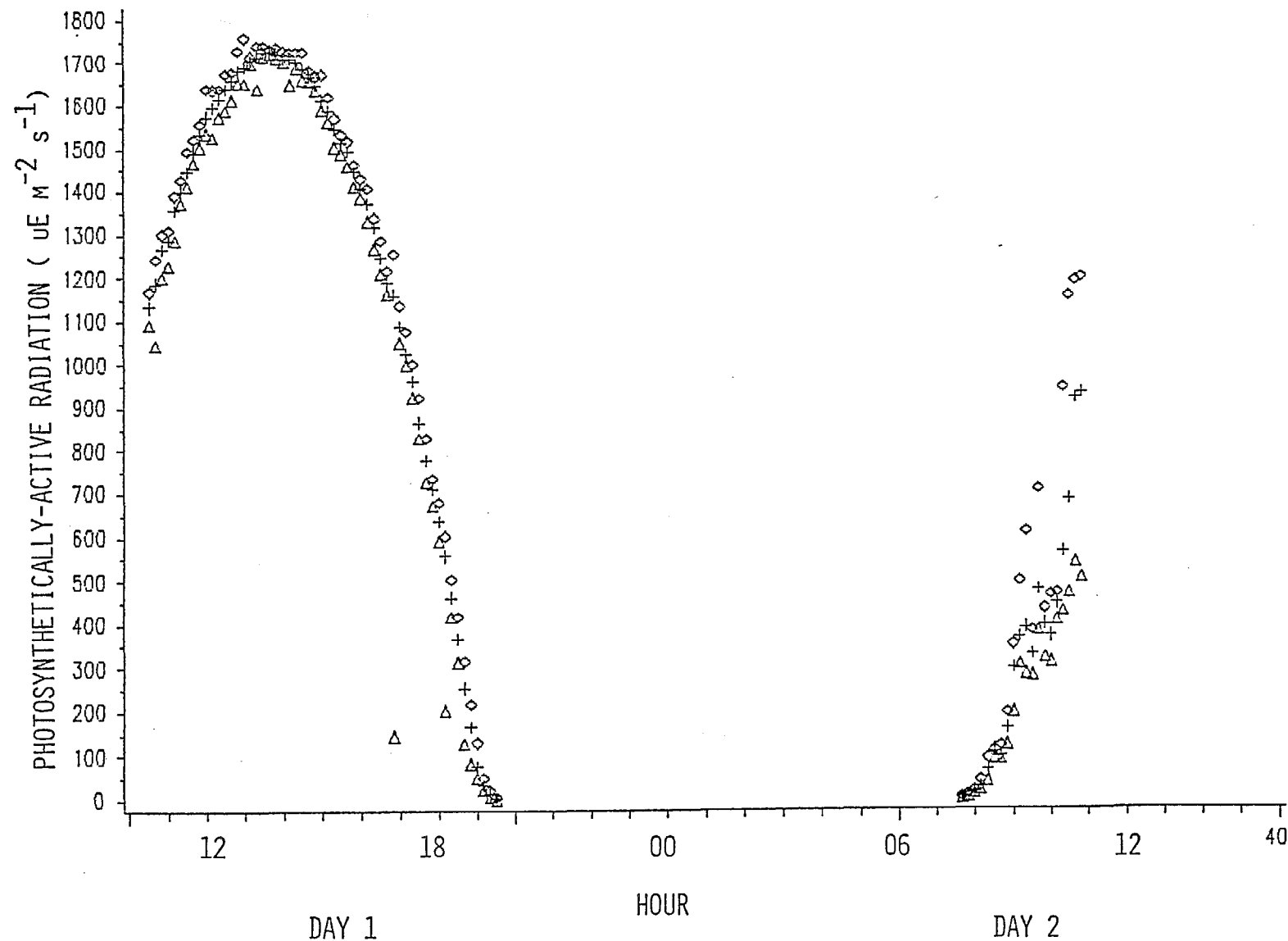


Figure F. Surface Light Fluctuations at Stress Site, 9/87. Maximum, minimum and mean values of surface photosynthetically-active radiation for each minute interval are represented by different symbols.

# CHAMBER OXYGEN CONCENTRATIONS, STRESS SITE, 9/87

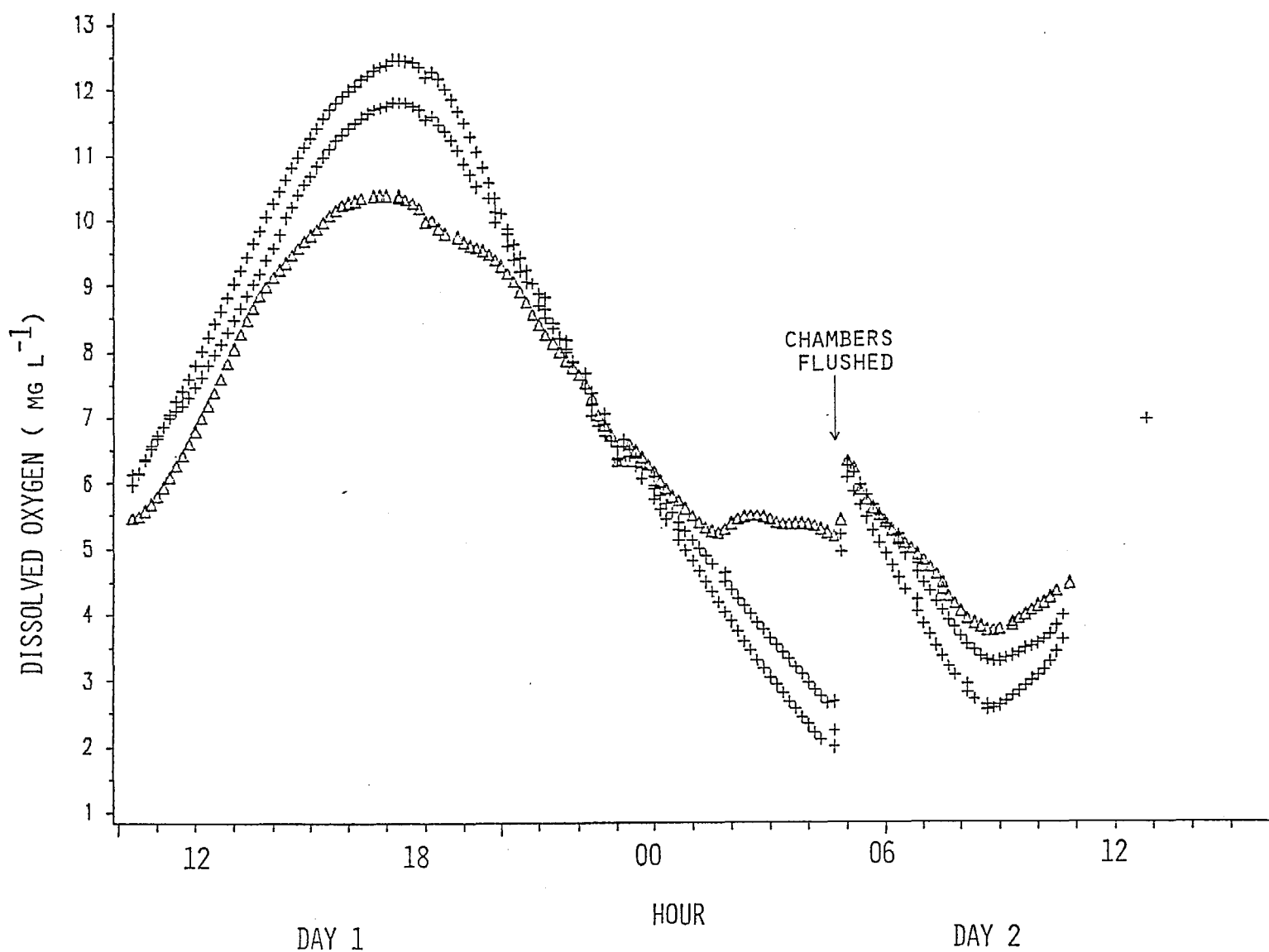


Figure G. Chamber Oxygen Concentrations, Stress Site, 9/87. Time expressed as decimal hours on a 24-clock. 00 is midnight.

# DAYTIME OXYGEN FLUCTUATIONS AT STRESS SITE, 9/87

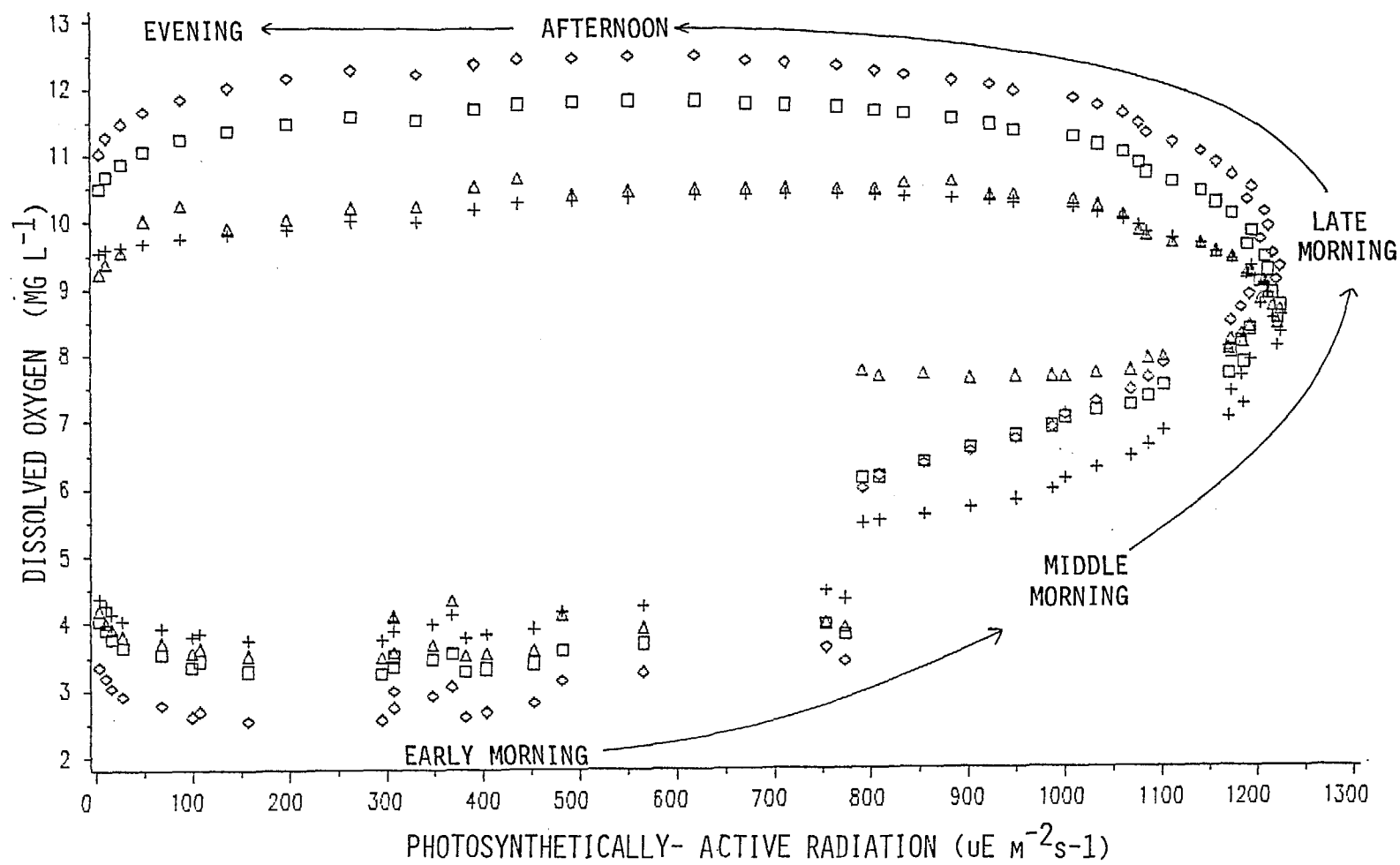


Figure H. Diurnal Cycle of Net Oxygen Fluxes in Chambers at Stress Sites. Arrows identify portions of day related to each group of data.

# NIGHT-TIME OXYGEN CONSUMPTION AT STRESS SITE, 9/87

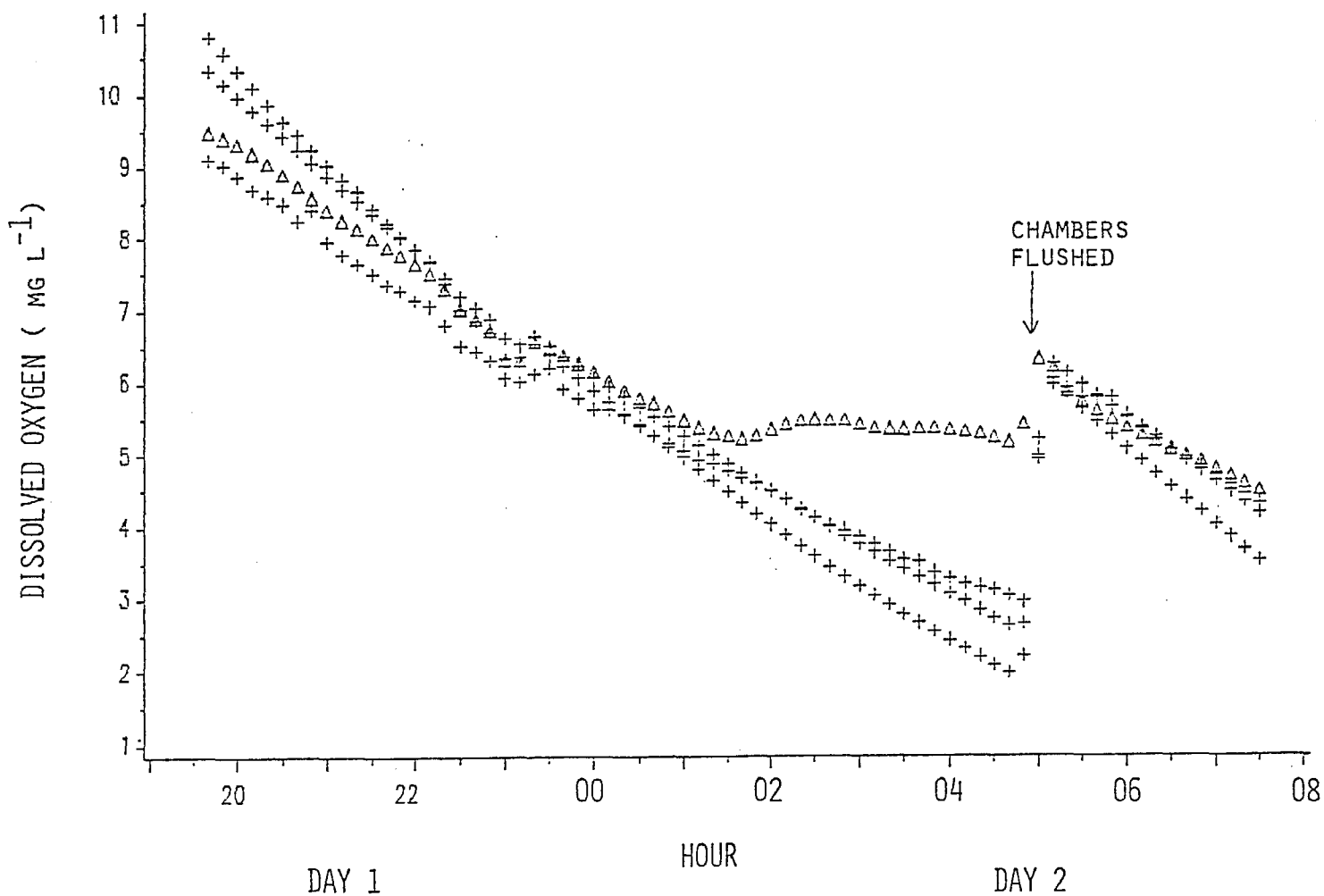


Figure I. Night-time Oxygen Consumption at Stress Site, 9/87. Time is expressed as decimal hours on a 24-hour clock. 00 is midnight.

# SURFACE LIGHT FLUCTUATIONS AT SEWAGE SITE, 9/87

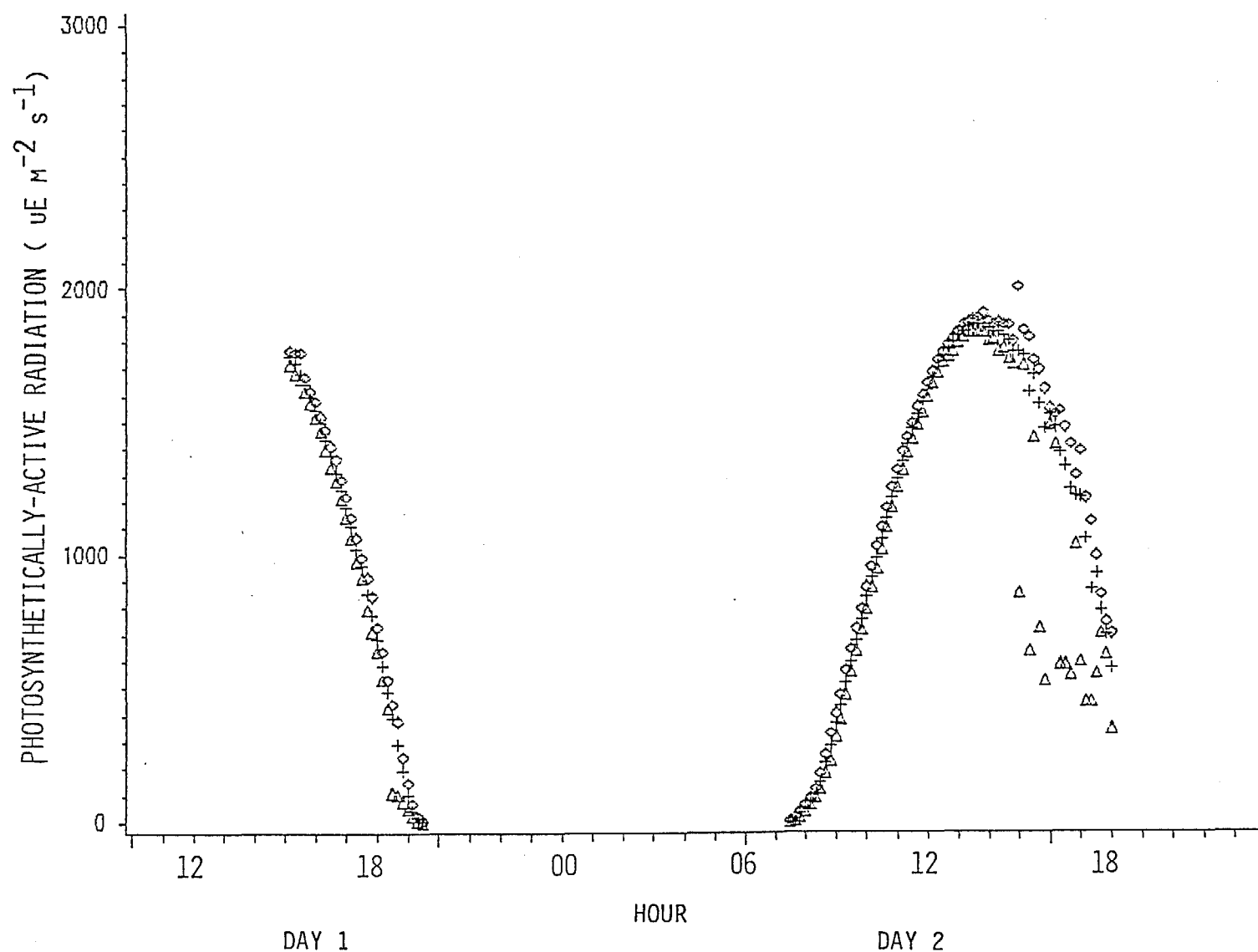


Figure J. Surface Light Fluctuations at Sewage Site, 9/87. Maximum, minimum, and mean PAR values for each 10-minute logging interval represented by different symbols.

# CHAMBER OXYGEN CONCENTRATIONS, SEWAGE SITE

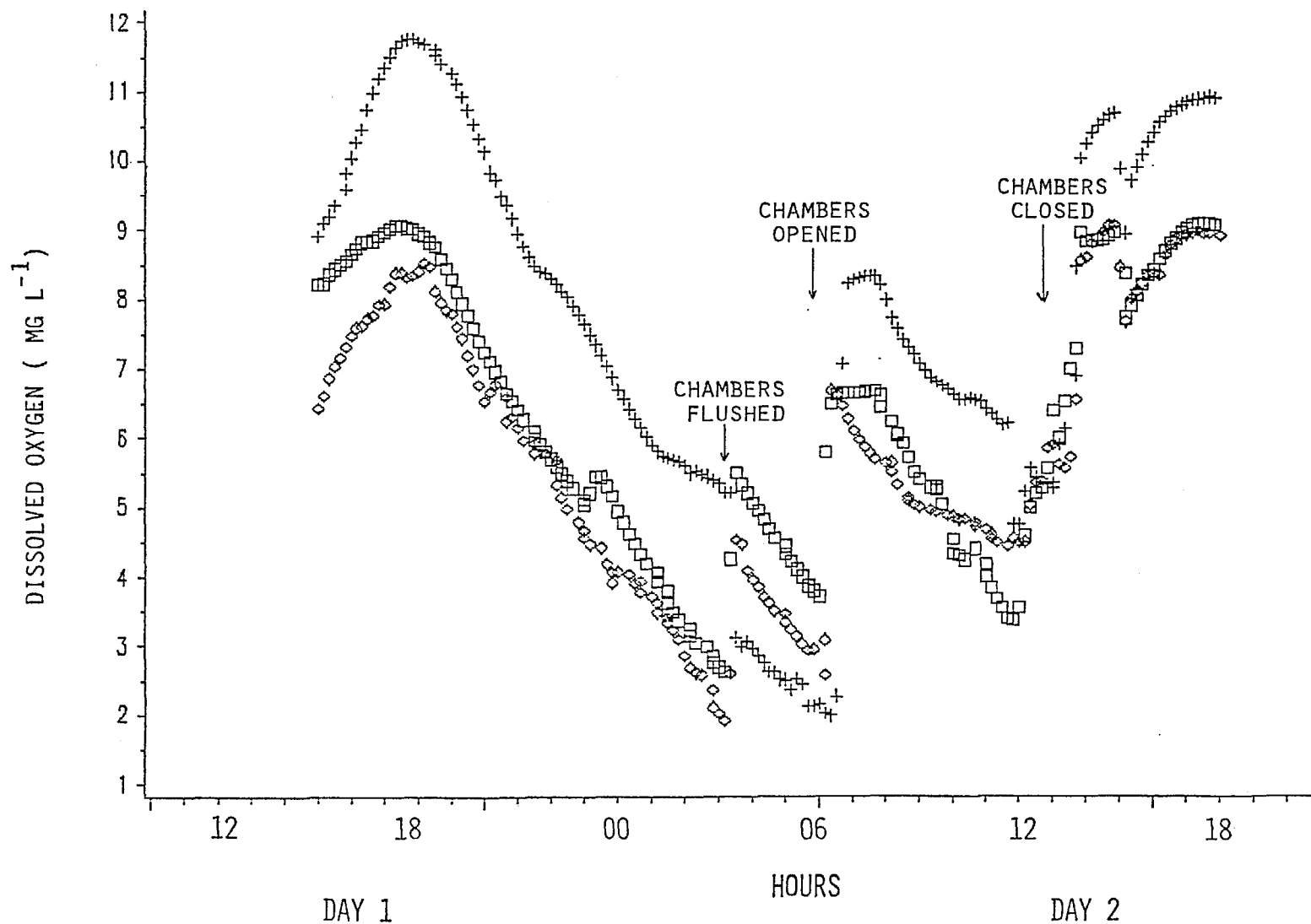


Figure K. Chamber Oxygen Concentrations, Sewage Site, 9/87. Chambers opened when exposed by falling tide at 0630. Chambers closed when reflooded at 1300 h.

# NIGHT-TIME OXYGEN CONSUMPTION AT SEWAGE SITE, 9/87

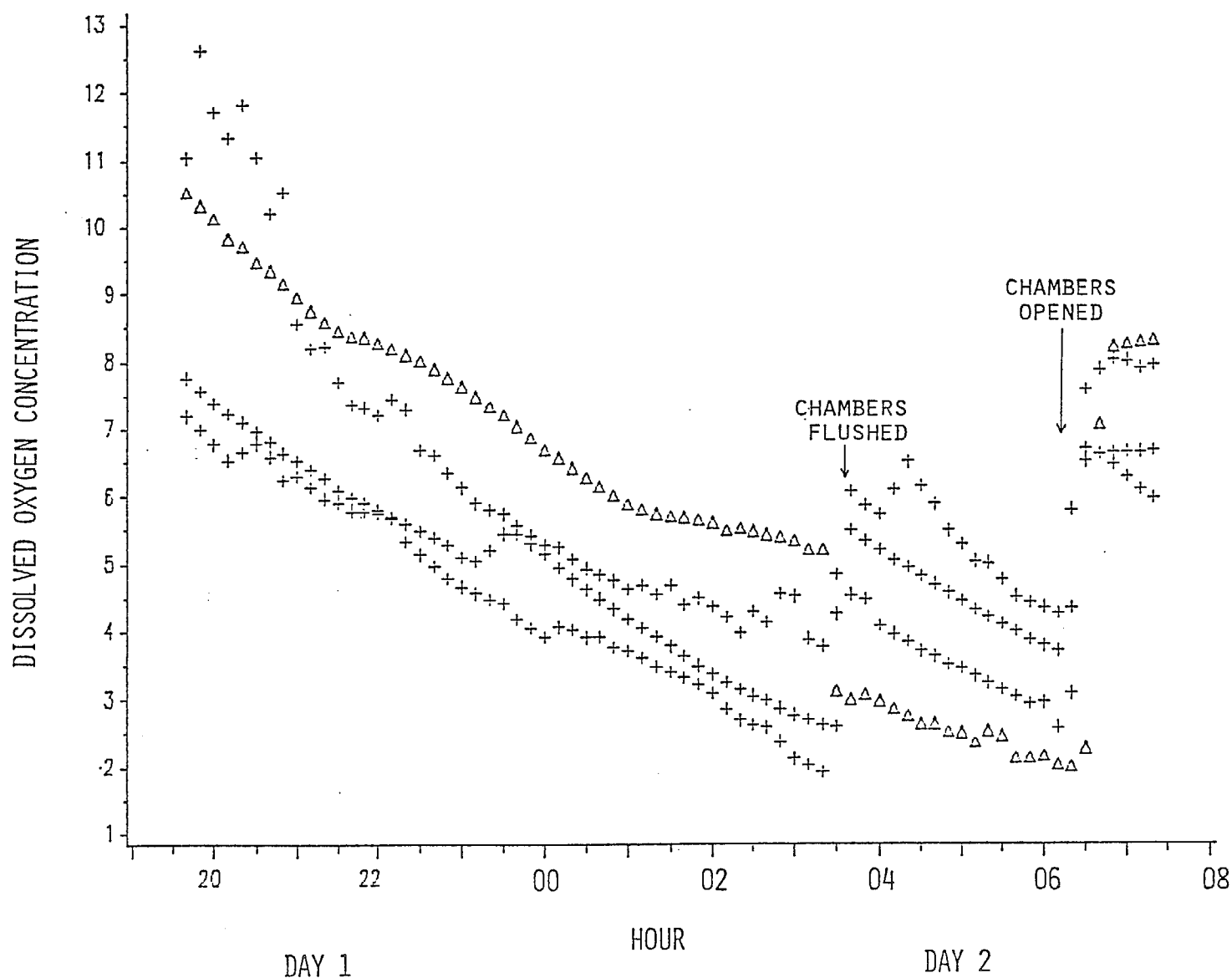


Figure L. Night-time Oxygen Consumption at Sewage Site, 9/87. Time expressed as decimal hours. Chambers flushed at 0320 to restore oxygen concentrations to near-ambient levels. Chambers exposed by tides at 0700 h.

# DAYTIME OXYGEN FLUCTUATIONS AT SEWAGE SITE, 9/87

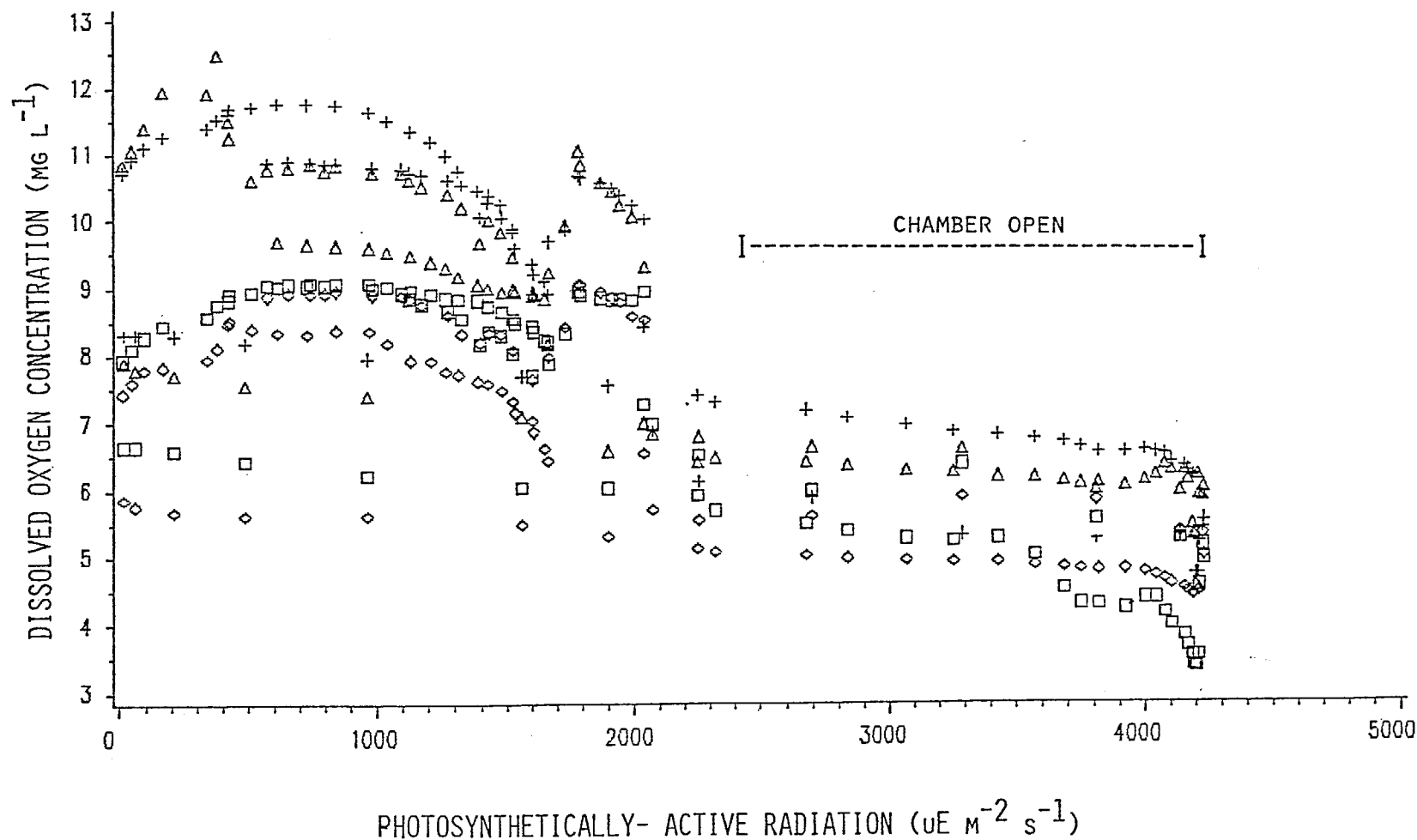


Figure M. Daytime Oxygen Fluctuations at Sewage Site, 9/87. PAR values greater than 2000 result from emersion of bottom light probe.

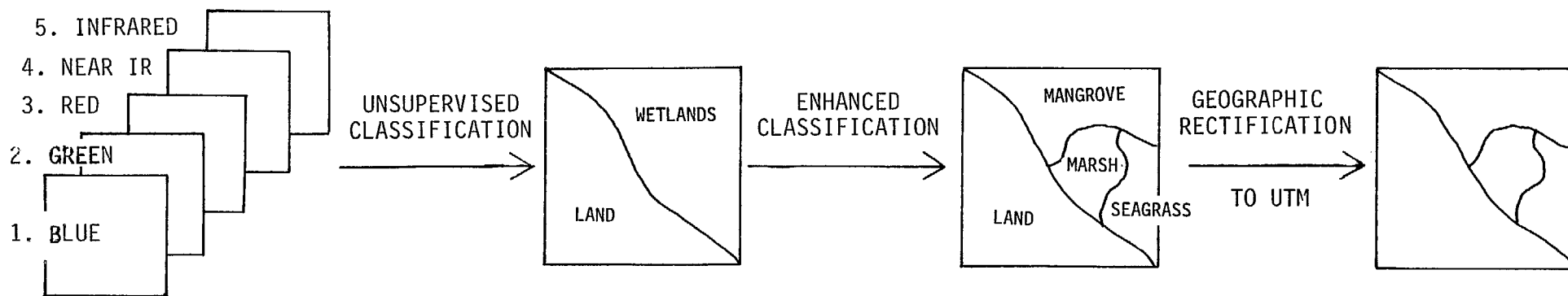


Figure 1. Original approach to MRGIS data formatting.

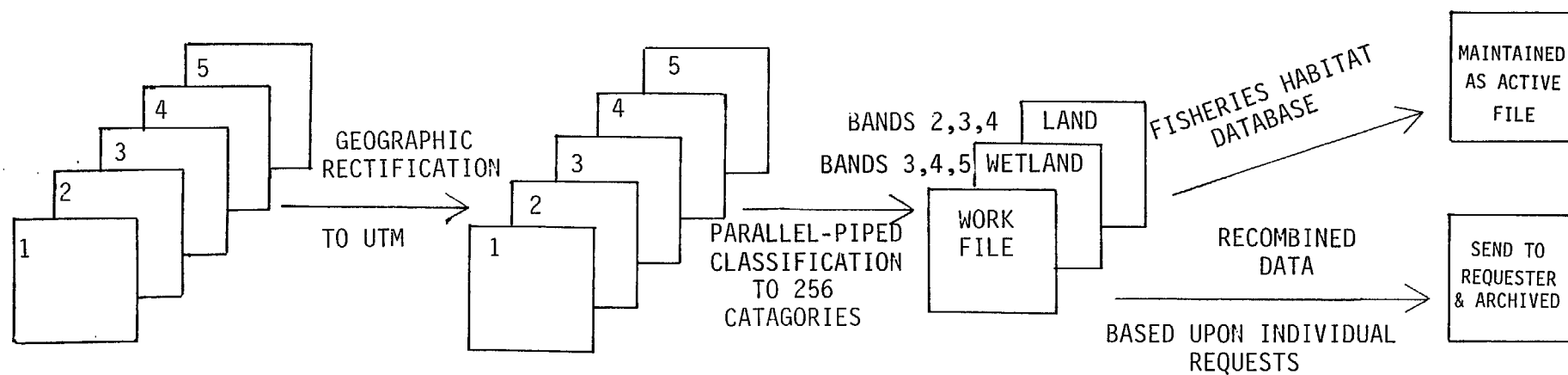
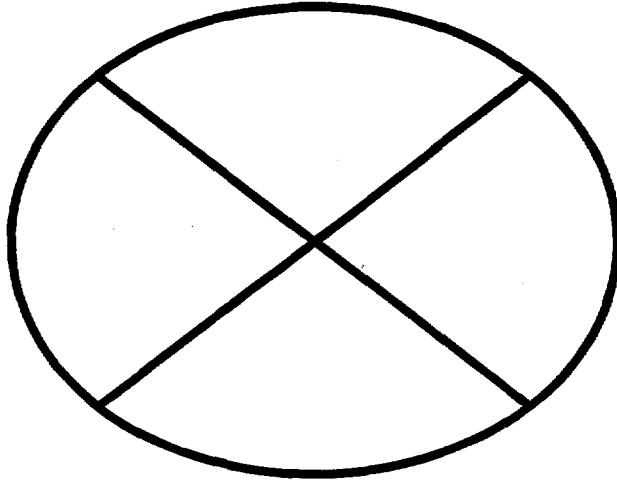


Figure 2. New approach to MRGIS data formatting.

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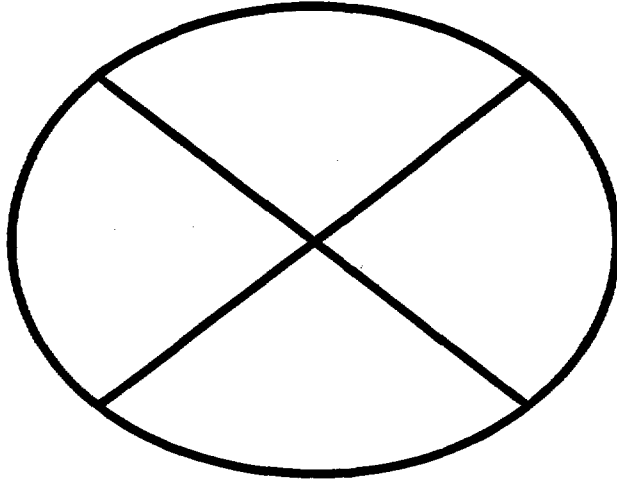
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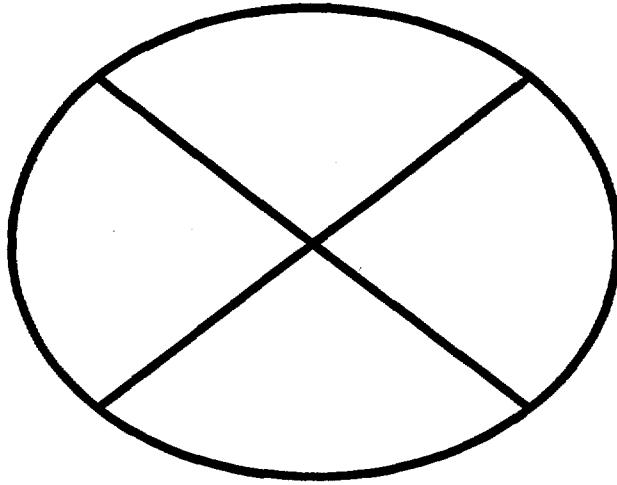
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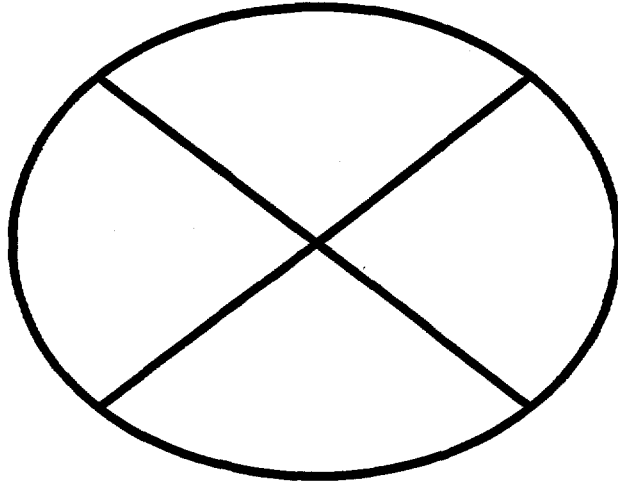


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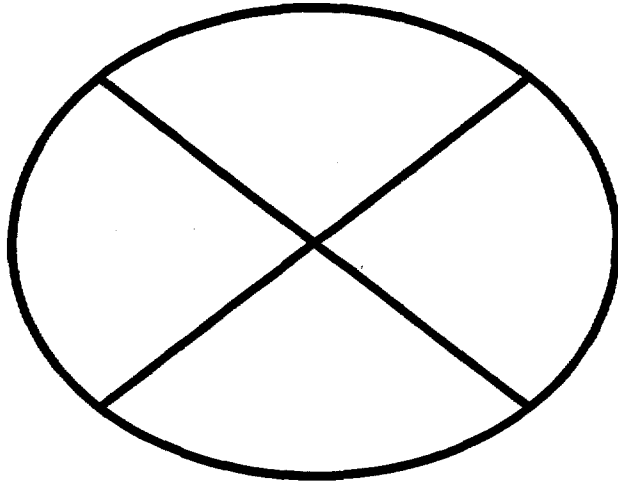


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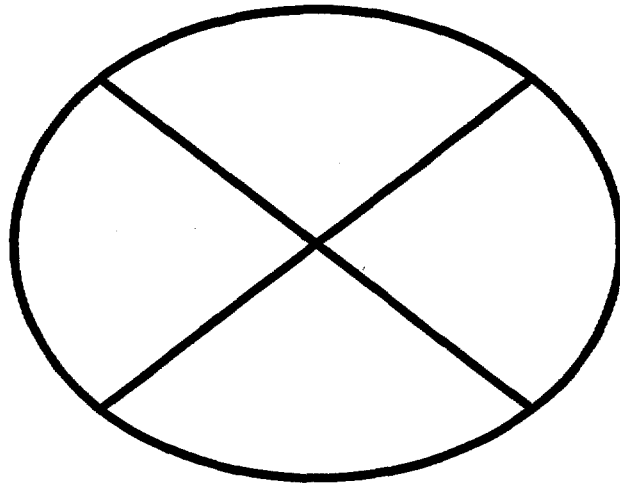
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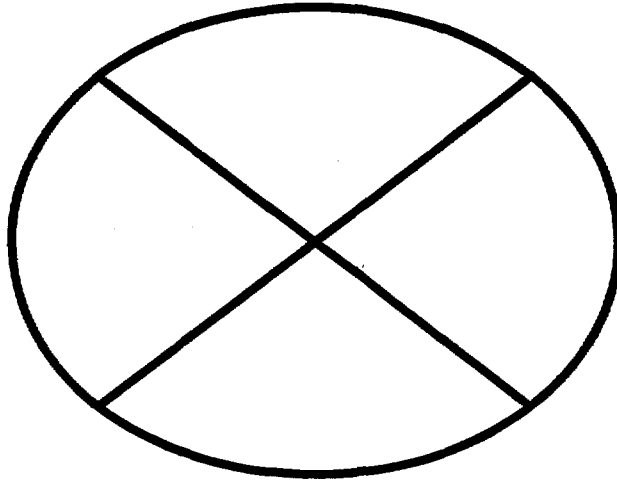
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L.A. : 365805.5,3066750

Figure 9A. SEAGRASS ANALYSIS FOR NORTHERN TAMPA BAY

WHITE Water



Land



Marsh/mangrove



Seagrasses (1982)



Seagrasses present in 1948  
but absent in 1982

Total seagrass coverage in 1948 was 16,790 acres. Coverage in 1982 was 7,053 acres. This represents a seagrass loss of 58%.

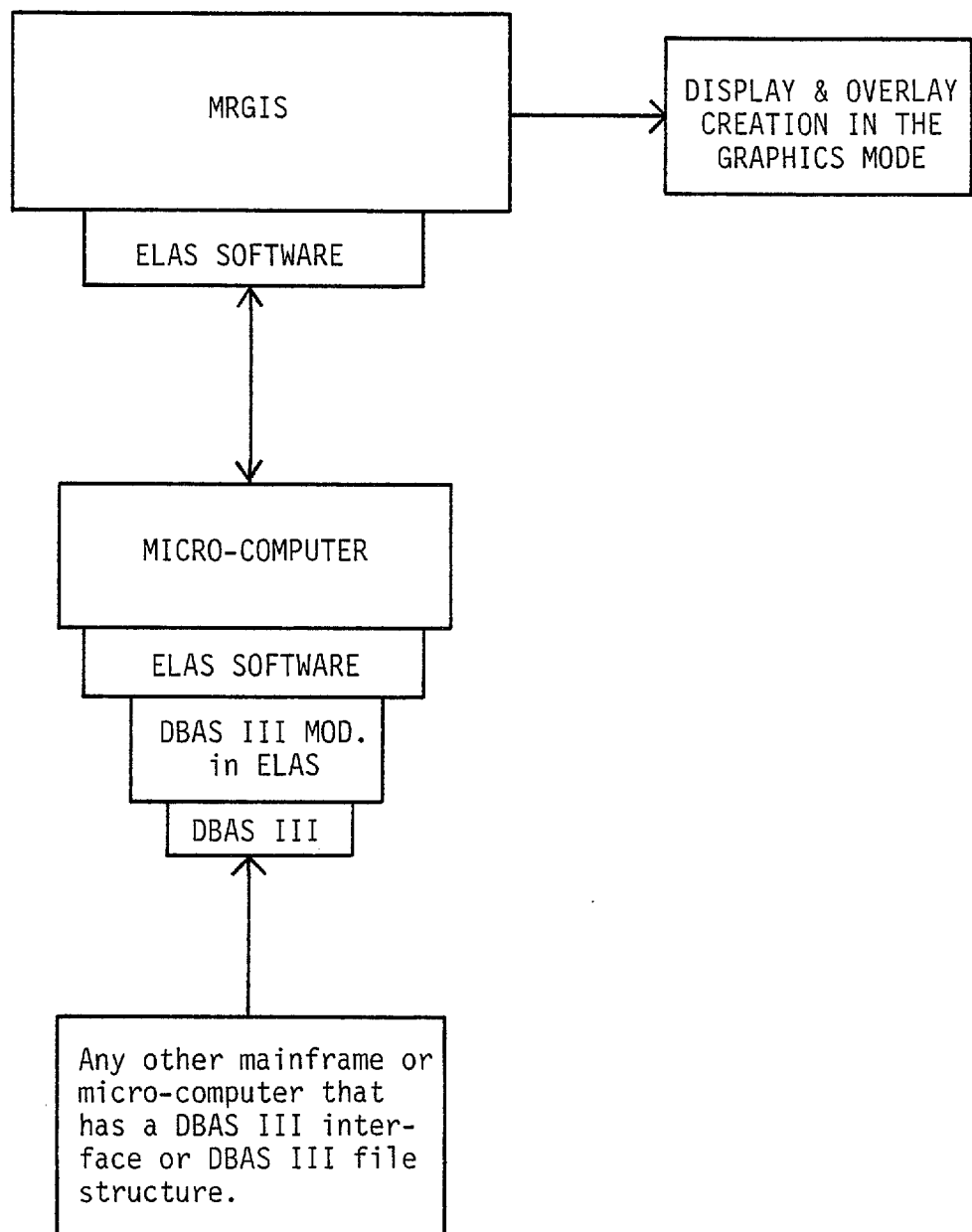


Figure 10. Micro-computer interface with the mainframe.

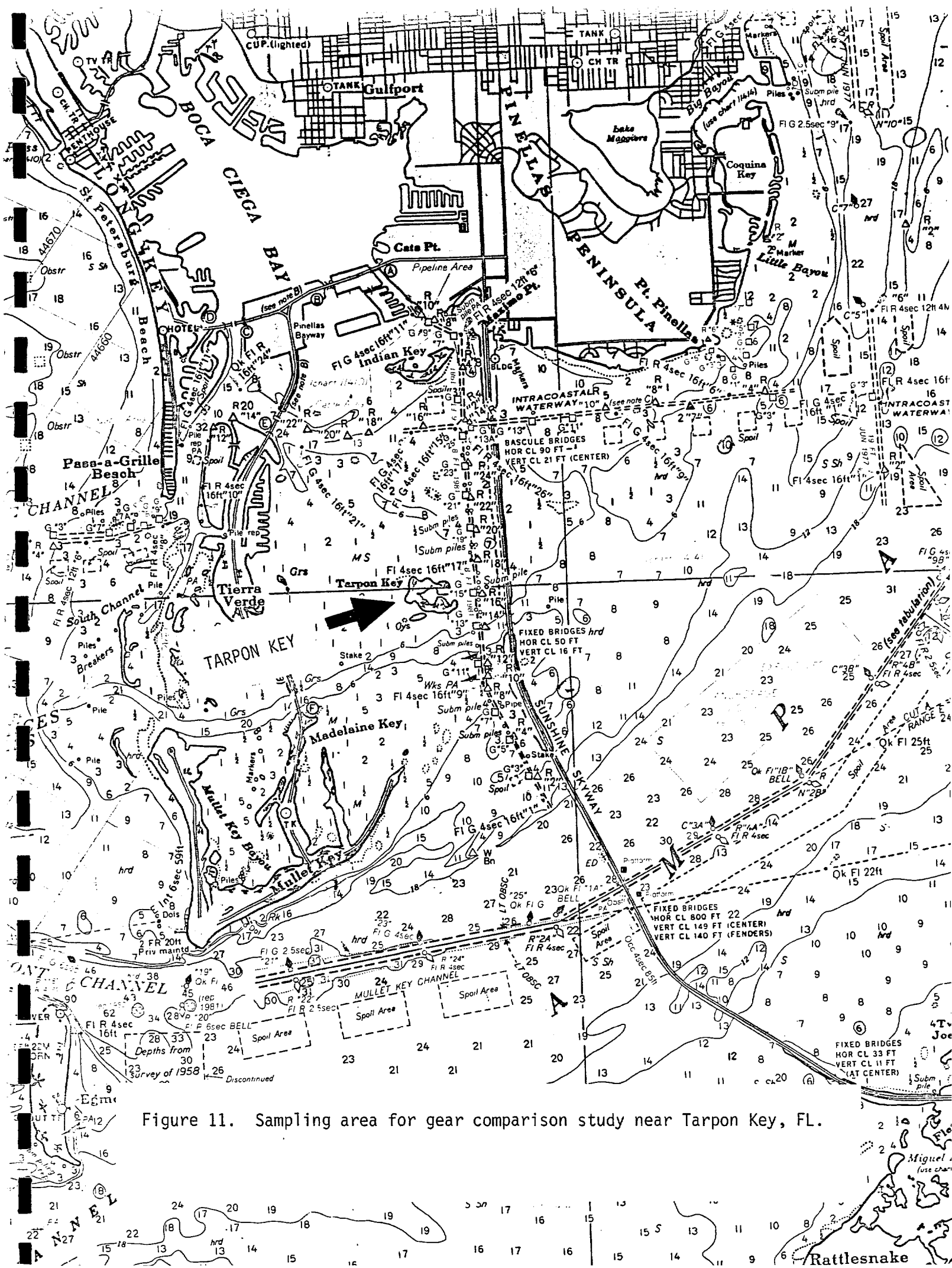


Figure 11. Sampling area for gear comparison study near Tarpon Key, FL.

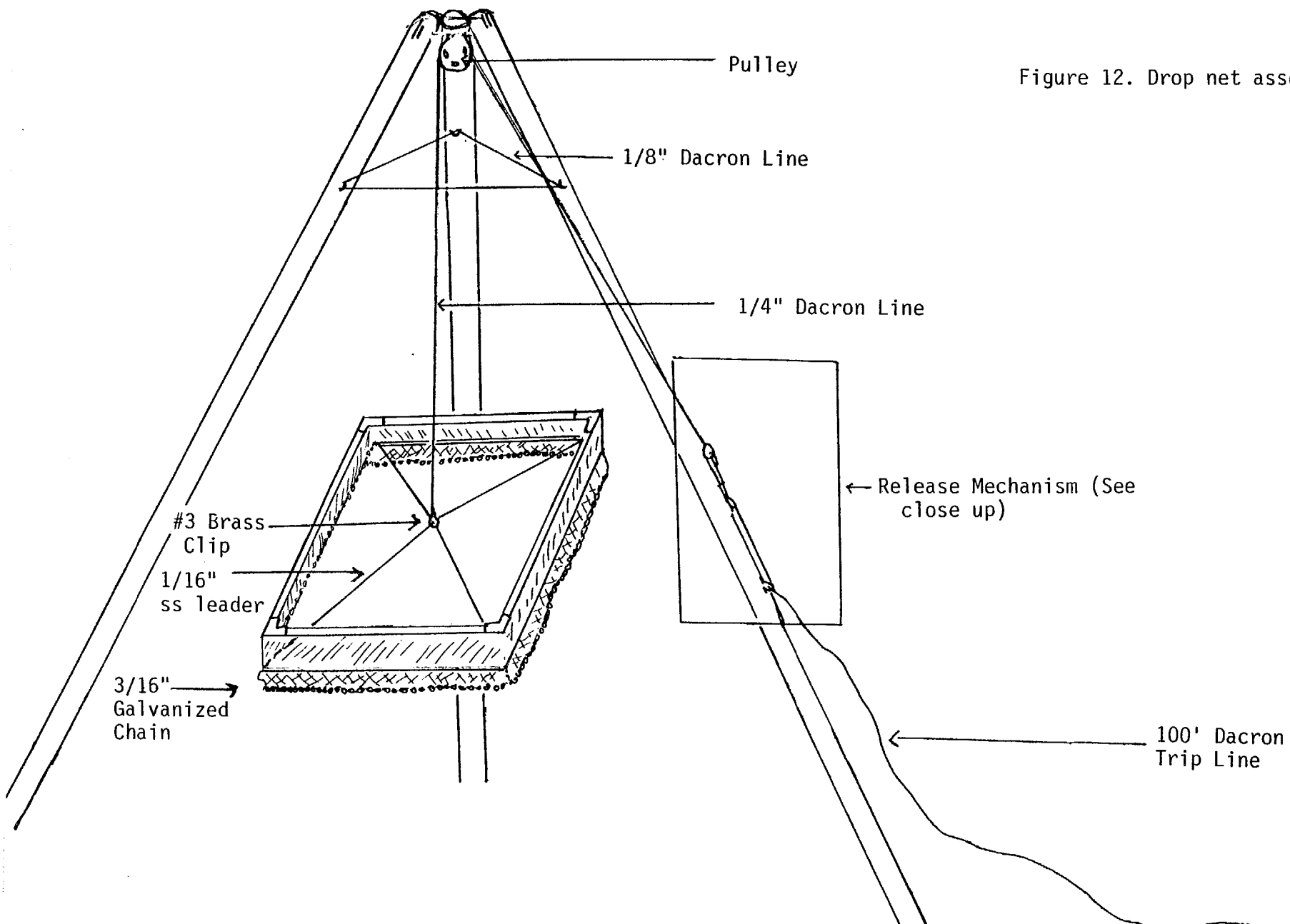


Figure 12. Drop net assembly.

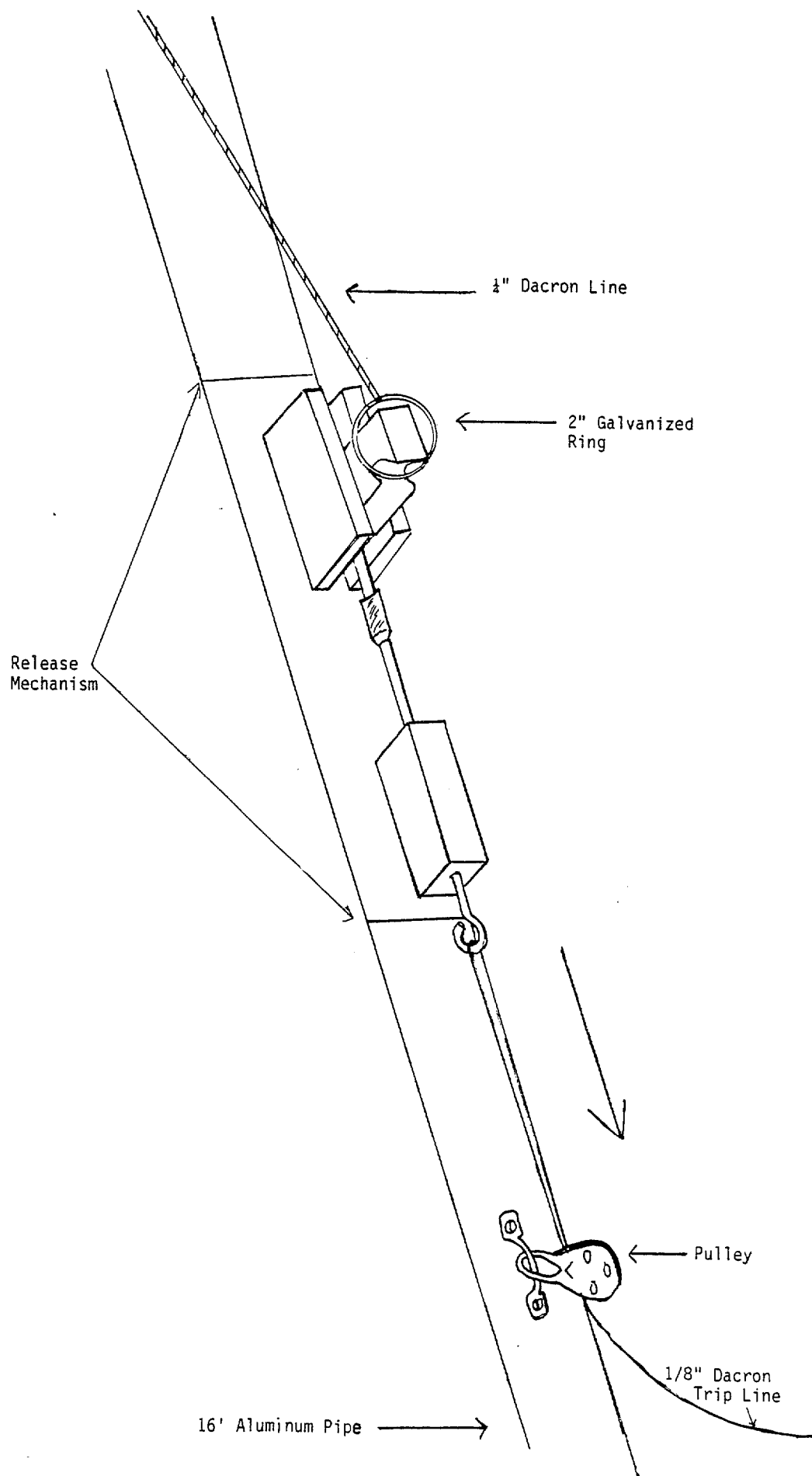


Figure 13. Close-up of tripod release mechanism

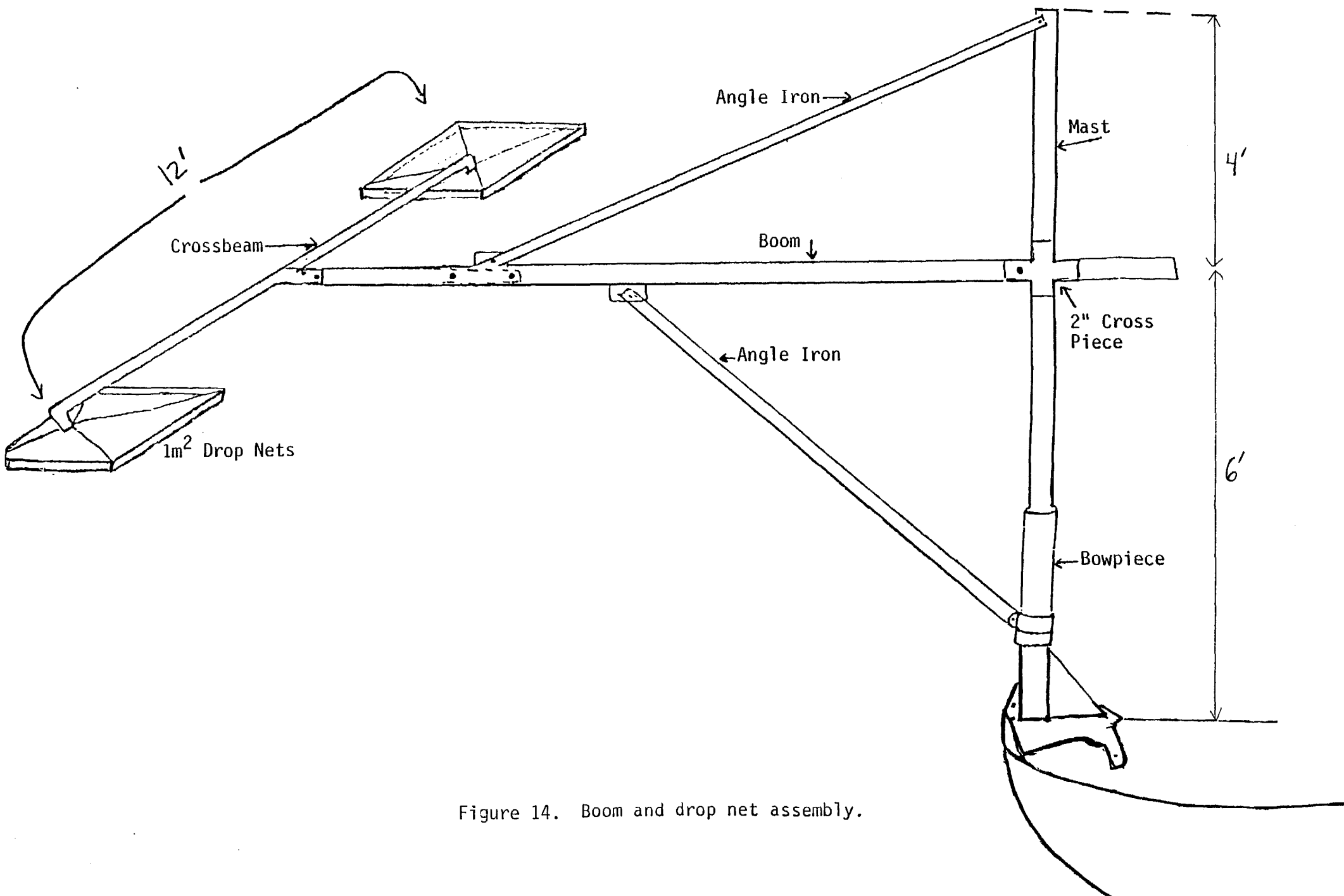
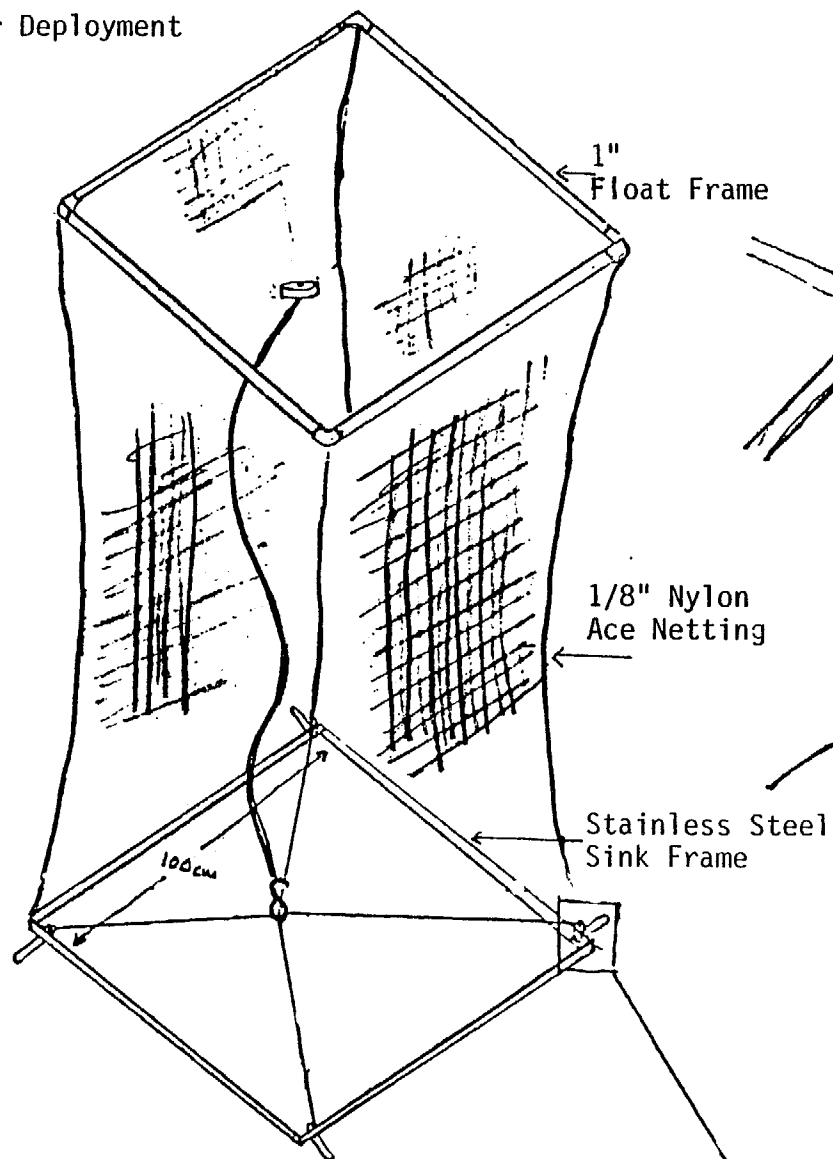


Figure 14. Boom and drop net assembly.

After Deployment



Before Deployment

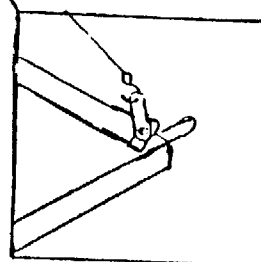
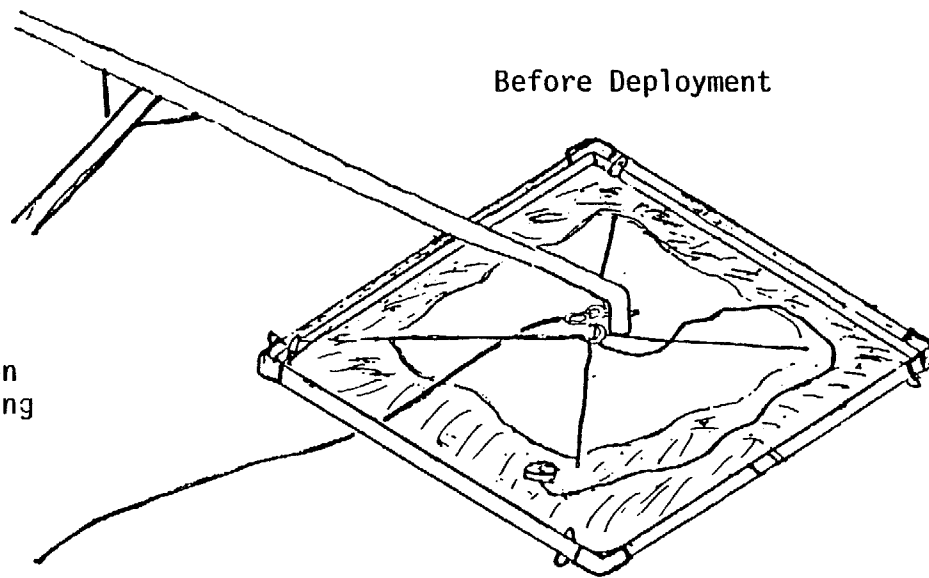


Figure 15. Drop net deployment detail.

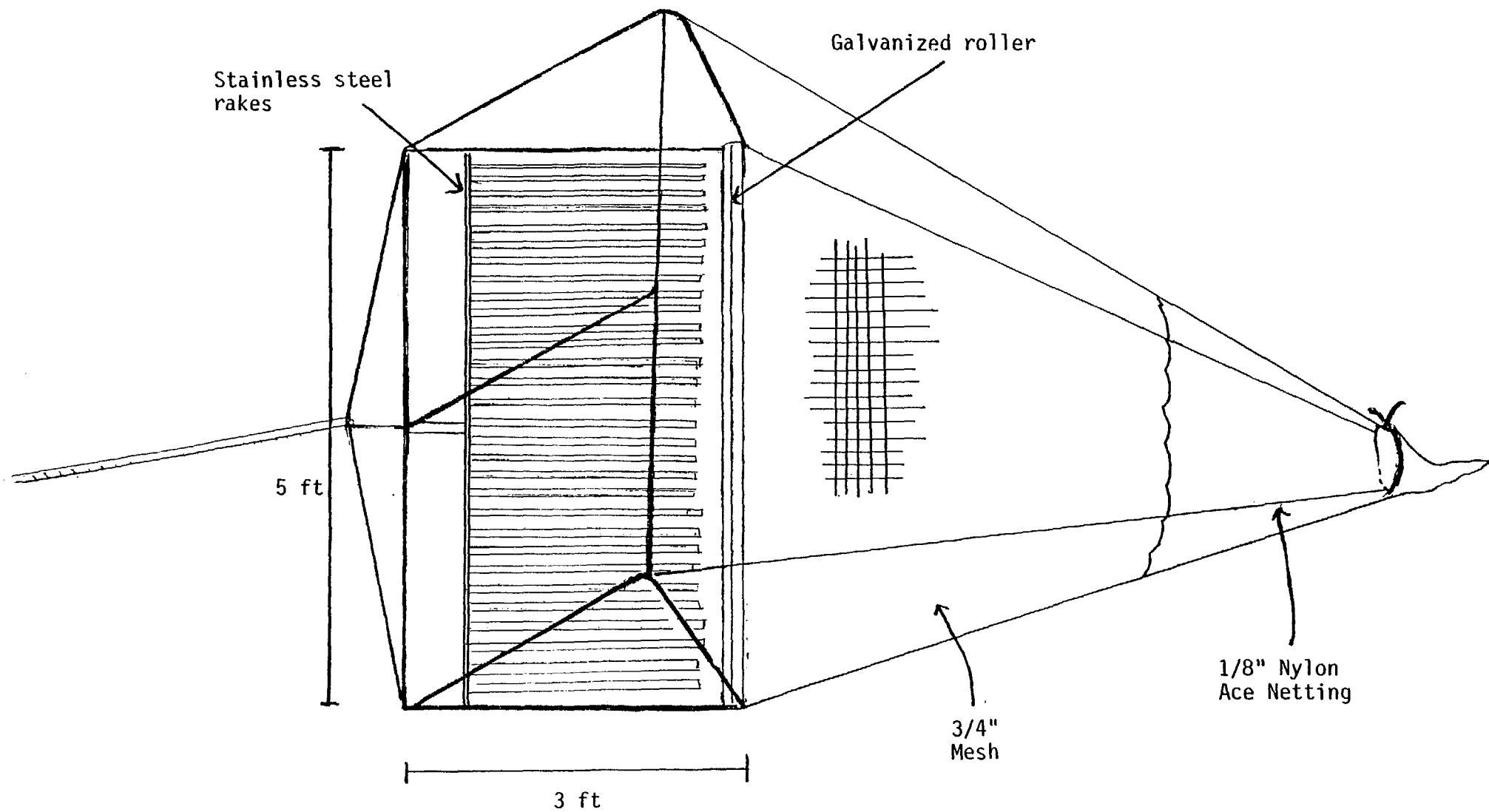


Figure 16. 5' roller-rigged shrimp trawl.

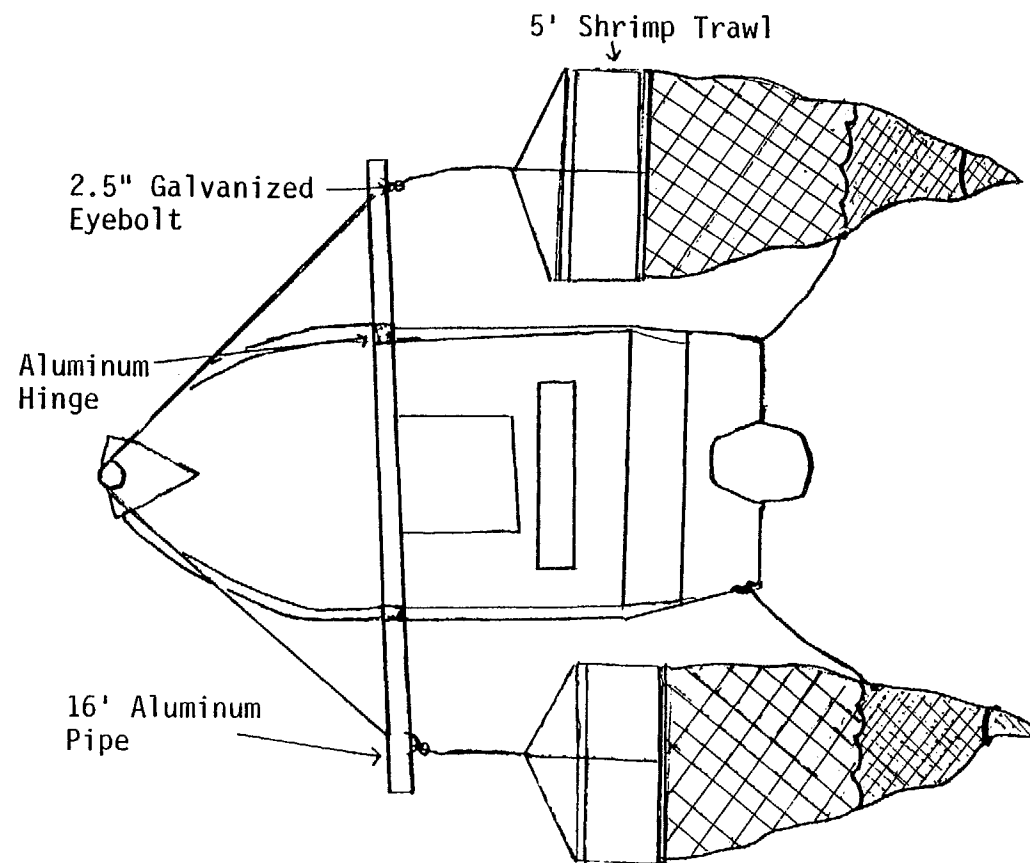


Figure 17. Towing configuration of roller-rigged shrimp trawl.

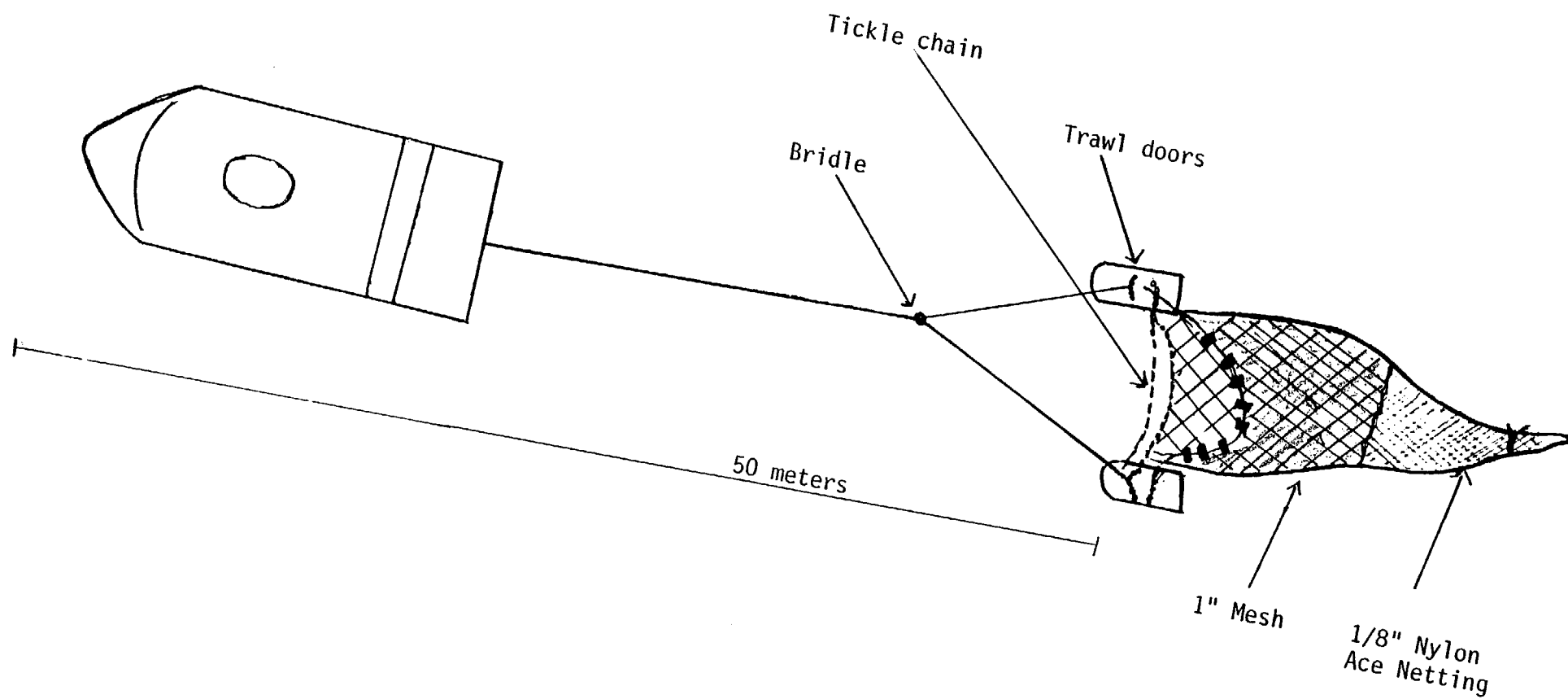


Figure 18. Towing configuration of 6.1m otter trawl.

## JUVENILE RED DRUM POPULATION ESTIMATES

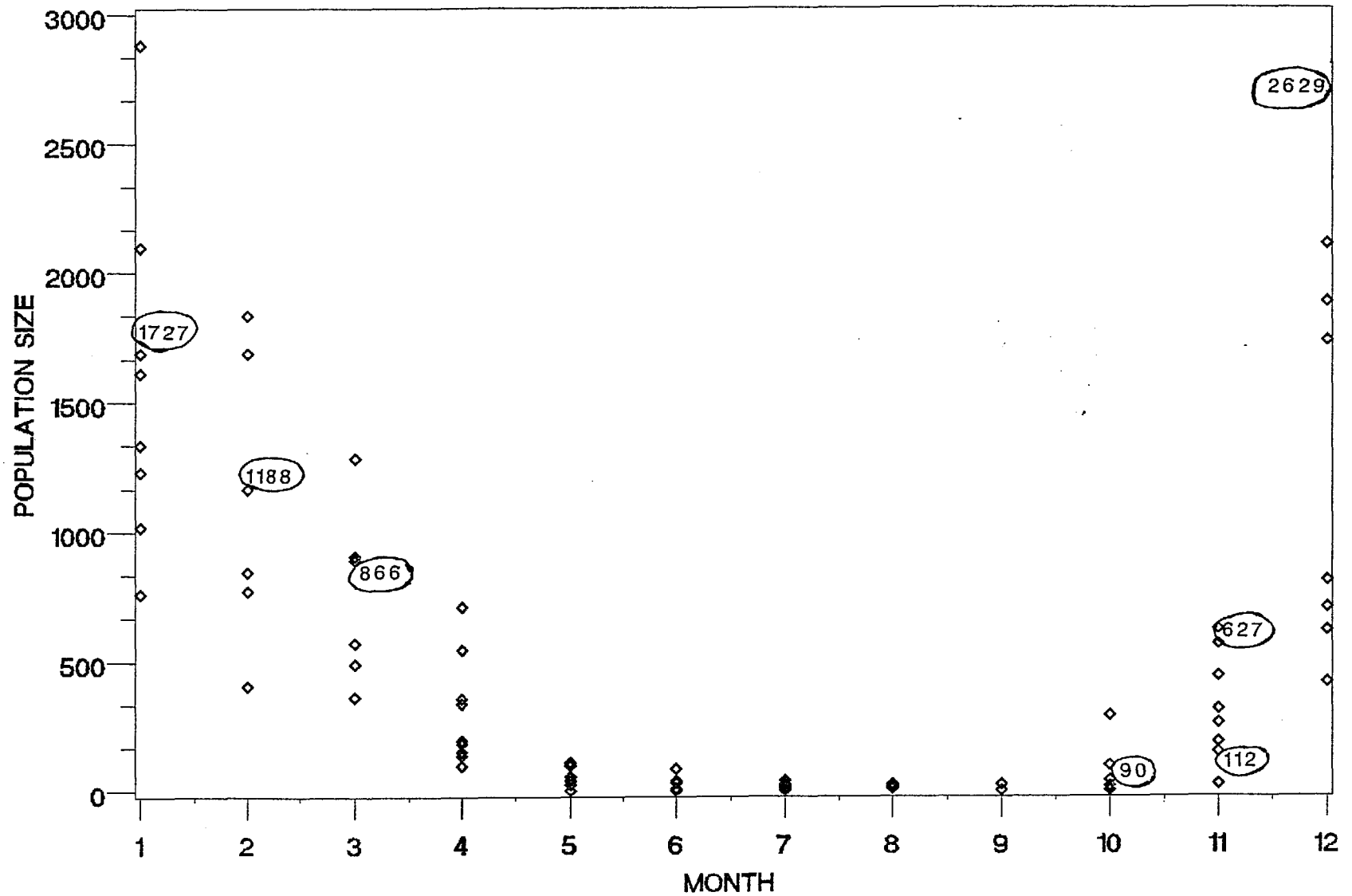


Figure 19. Juvenile red drum population estimates.

# Bay shows slight progress in the battle for survival

By JON EAST  
Staff Writer

Scientists have their own language to describe the waters Mark Taylor calls home, but terms like dissolved oxygen, chlorophyll A and coliform counts don't mean much to him. Taylor's a fourth-generation fisherman, and he understands Tampa Bay in a different way.

He measures it everytime he empties his nets. "We have to wear oil coats," Taylor says, wincing as he describes it. "The stuff we pull up burns so bad you don't even want it to touch you."

When the season is right, Taylor moves his boat into the middle stretches of Tampa Bay and drops the nets in search of shad. What he pulls aboard each time, though, is more than fish. The webbing of his nets is caked with muck, courtesy of the bay's bottom, where sea grasses have died. He says his crew members wear rain jackets and rubber gloves for protection, and their eyes often burn when they begin peeling the muck away.

Taylor needs no laboratory analysis to draw his conclusions: "Some of these sediments, I don't know what they are, but they're not good for us."

By some gauges, the environmental quality of Tampa Bay has improved over the past decade, according to a team of marine-related professionals who gathered Saturday to talk about the troubled urban waters that surround us. But the intricate community of marine life that is a playground and source of commerce for the Suncoast is still behind in its battle for survival, they say, and the increasing stresses of growth are threatening it as never before. Amid all that, those who plot strategy say still too little is known.

"From the biological aspect, we don't understand what we can do (for marine life) once we clean up the water quality," says Ken Haddad, a marine research lab biologist with the state Department of Natural Resources (DNR). "We simply don't know."

The setting Saturday was Bayboro Harbor, at the University of South Florida St. Petersburg campus, and many of the people considered experts in the bay environment were there to draw conclusions about its health. Bay Day, as it was called, was also an attempt to gather attention to something that those who study the bay have known for years: Growth has harmed it. In the past 50 years, 81 percent of the sea grasses have died, 44 percent of the important mangrove and salt marsh borders have been destroyed, bacteria levels have prompted occasional swimming and shellfishing bans and fish populations have declined.

"We're playing catch-up," says Jacob Stowers, assistant Pinellas County administrator and a member of the Agency on Bay Management. "The people (who planned growth) didn't know they weren't doing right."

State of the Bay '86, though, brought some encouraging signs.

Hillsborough Bay, the heavily damaged finger of Tampa Bay that extends up into the Port of Tampa, has shown improvements in water quality over the past decade, according to research compiled by the Hillsborough Environmental Protection Commission. Since the city of Tampa opened its advanced sewage treatment plant and began pouring cleaner effluent into the bay, the water there has become clearer and bacteria and algae have declined. Lower Tampa Bay, in the relatively pristine areas south of the Sunshine Skyway Bridge, has also shown some water quality improvements in the past decade, according to other research.

The regulatory emphasis over the past decade on cleaning up or eliminating sewage effluent entering Tampa Bay has paid some dividends, according to Rick Garrity, district manager of the state Department of Environmental Regulation. But as the metropolitan areas surrounding Tampa Bay continue to grow, another unchecked source of pollution looms as a more intimidating threat, he says.

Stormwater that runs across fertilized lawns, oil-coated streets and through overloaded sewer systems pours into the bay without treatment.

"Despite all the improvements we are making in point sources (sewage and industrial discharges), nonpoint sources are definitely going to have to be on the agenda for the future," Garrity says.

State legislators are considering ways to control stormwater runoff in this year's session, but cities and counties have fought it because the expense is potentially enormous. Short of actual treatment, stormwater plans would require holding ponds that help filter out contaminants through vegetation. In Tampa, Mayor Bob Martinez has proposed a stormwater control plan that calls on residents to pay a monthly utility fee.

Even with the attention on cleaning up water that enters Tampa Bay, however, biologists say they are still not sure what can be done to restore much of the marine life that has already left it. Tampa Bay is an estuary that serves as a breeding ground for 70 percent of the area's recreational and commercial fish. Each part of that estuarine system — the vegetated, sloping shorelines, the underwater grass beds, the mixture of salt and fresh water — is linked to the overall health.

"No research is available to be able to tell what's going on biologically in the bay," DNR's Haddad says. "We need to set up long-term programs."

Commercial fisherman Taylor and his remarks about bay sediments provided illustration for another area where research is lacking. Carl Goodwin, a U. S. Geological Survey hydrologist, says bay bottom land can continue to plague water quality for decades even if pollutants never again enter Tampa Bay.

Goodwin says contaminants found in bay sediments are thousands, even tens of thousands, times more concentrated than those measured in water. When tides, currents and turbulence stir up water,

Attachment 1

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APR-21-86

"I think everyone here knows the problem," says Taylor, who was called to Bay Day to serve on a panel of non-scientists. "For those of us who have been here all our lives, it's sort of a remember when, you might say. . . . Whatever the competing interests, we have a common interest in ensuring the bay is healthy and productive."

That sediment pollution is the least understood and potentially most threatening part of the bay system, he contends.

# Lost lagoons

PART 1 — RIVERS OF WASTE

## Life-filled waters turn to cesspool

By Don Wilson

SENTINEL OUTDOORS WRITER

Six thousand years ago the lagoon system known collectively as the Indian River Lagoons was formed, made up of the Indian River, Banana River and Mosquito Lagoon. The 150-mile tidal pool network evolved into the richest marine environment of its kind in North America, with more than 400 species of fish and 260 types of shellfish.

Today, the Indian River and Banana River are dying, and Mosquito Lagoon's water quality has suffered. The effects are being felt in the six coastal counties that line the lagoon, from Palm Beach County on the south to Volusia County on the north.

Man has turned the lagoon system into a gigantic refuse pit for his liquid wastes — treated sewage and stormwater runoff

loaded with fertilizers and pesticides.

Everyone thought that, being pumped into a lagoon, such waste would soon flow out to sea. They were wrong.

Tidal flow in the 220-billion-gallon lagoon is so slight that scientists estimate only 15 percent of its water is exchanged with that of the ocean. Any purification caused by that flushing effect occurs within a mile or two of one of the lagoon's

four inlets.

So whatever man pumps into the lagoon stays put.

"What most people didn't understand was that it is not a river, so there is no flow," said Diane Barile, executive director of the Marine Resources Council of East Central Florida. "The Indian River is a dump — a sump. Anything you dump in there is going to stay there, unless it can evaporate."

Barile is one of the leaders of

a movement to halt the flow of pollutants into the lagoon and eventually restore its water quality. Their task is staggering.

In an average year, nearly 170 billion gallons of freshwater runoff and treated sewage flow into the lagoon. In times of heavy rainfall, the runoff is much greater.

The results are inescapable:

■ Estimates of sea grasses

killed by pollution range from 30 percent to 80 percent.

■ Cocoa, which once billed itself as the "Saltwater Trout Capital of the World," has long since abandoned the claim. Each year anglers complain about dwindling catches.

■ Each year large areas of oyster and clam beds are closed when massive freshwater runoffs raise bacteria levels.

■ The direct financial loss to commercial and recreational fishing is estimated at more than \$11 million annually.

In just 60 years man has unraveled a tapestry of life that had taken 6,000 years to evolve.

In Palm Bay the trout fishing is so poor that Barney Gottshall, a retired Air Force colonel, has hung up his fishing rod in disgust.

When Gottshall moved to Palm Bay Point in 1959, he could catch 15 to 20 sea trout in an hour or two of fishing from his backyard dock.

### Trout, redfish disappear

Today things are different.

"The last trout I caught out here was a year ago last February," Gottshall said. "I haven't caught a redfish in three or four years."

Once, he said, he could stand at the end of his 60-foot dock and see fish and crabs in the sea grass 7 feet below the surface of the clear water. Now the grass is gone, but the water is too dirty to see it even if it were there.

In addition, sediments carried by the runoff are rapidly filling in his section of the lagoon.

"At the end of my dock, the water used to be over my head," said Gottshall, who is 5 feet 7. "Now it's just up to my armpits."

"I used to catch big trout down there, but not any more," he said. "Now you could fish for a whole week and not even catch enough fish to keep a cat from starving."

The change has been so great that few realize what the lagoon once was.

For several hundred years, into the early 20th century, man's impact was limited. Only the hardest homesteaders settled along the lagoon's shores, and their effect was minimal.

Vernon Lamme, a longtime newspaperman and son of one of the first Merritt Island homesteaders, wrote in his book Florida Lore of fish dealers refusing to buy trout unless they were so long that they had to be bent to fit in the mouth of a fish barrel.

Red drum were so plentiful that nets and fishing poles weren't needed. Instead, a few men wielding clubs would wade out into the lagoon and corral a school of reds, herding them like sheep.

"We would rush toward the shore, driving the redfish ahead of us, and when they reached shallow waters they would all mill around, and we were able to pound them over their heads with our clubs. We could have killed any number, but we would take a dozen or more ashore and ... have a fish fry," Lamme wrote.

In the 1920s, however, that began to change.

### Canals, causeways hurt

Entrepreneurs began draining freshwater swamps for development, and their drainage canals

funneled huge amounts of nutrient-laden fresh water into the fragile lagoon.

Causeways were built across the lagoon that helped cut off its circulation.

When the developers succeeded in luring thousands to the new Eden, local governments found themselves awash in waste, which they pumped into the lagoon.

During the years the runoffs and sewage increased with the growth of agriculture operations and developments. Now they are at critical points.

St. Johns River Water Management District engineers say that a 10-year storm would result in 2.9 trillion gallons being diverted to the lagoon through just one canal, the C54 Canal on the Brevard-Indian River county line. A 10-year storm is one that deposits 8 inches of rainfall on the area in 24 hours, usually a hurricane.

That's enough water to cover the entire city of Orlando to a depth of 3 feet.



Thomas

CRAAND 520  
54.0. Nov. 16, 1971

see pg 39

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"And that's just one canal," Barile said. "The Melbourne-Tillman Canal is even longer."

Such an enormous volume of fresh water is, itself, without considering pollutants, a serious problem for the river. Organisms accustomed to certain salinity lev-

els cannot cope with massive doses of fresh water.

Richard Thomas, an educator from Sebastian and part-time commercial fisherman, can vividly describe what happens to such creatures.

"You've got organisms out here that are used to 25 parts per thousand salt content," Thomas said. "He's a slow mover — he's not to crawl or swim real slowly — and, all of a sudden, here comes this tide that's solid fresh water. Bam! He's had it."

Barile said that was what happened to Indian River clams in September 1985, when a one-two knockout punch killed an entire generation of the shellfish.

Unusually heavy rainfall lowered salinity levels, stressed the clams and forced them to spawn.

## Floodgates spill out death

Then the St. Johns River Water Management District opened flood gates to remove surface waters from the river basin, and the water went rushing into the lagoon.

"The gates were opened while the larvae were in the water, and that slug of fresh water killed the larvae," Barile said. "We didn't have clams for the next season."

When drainage canals dump billions of gallons of runoff into the lagoon at once, they create another problem. The cascading torrents also carry huge amounts of suspended silt particles that block the sunlight that sea grasses need to survive.

The same runoffs contain excess nutrients from fertilizers that combine with the nutrients in the nearly 12 billion gallons of treat-

ed sewage that 19 sewage-treatment plants empty into the lagoons each year. One University of Florida study estimated that the combined nutrient loading from both runoffs and sewage discharges totals 1 million pounds annually.

Those nutrients supercharge the water and lead to large-scale algae blooms that also cover the

surface and block sunlight, killing more sea grasses.

Brevard County biologist Conrad White compares the algae bloom process to "cutting a real heavy lawn and letting the stuff just lay there." White has been taking inventory of the lagoon's grass beds to determine how much grass is left.

Just as that hypothetical lawn would die, so has grass in the lagoon.

The Florida Department of Natural Resources estimates that 30 percent of the lagoon's grasses have vanished.

Thomas, who has been roaming the lagoons for 30 years in his commercial fishing boat, said he thinks that the sea grass loss is greater.

"I say that's a joke. We're looking at 80 percent loss. It's habitat destruction, plain and simple," he said.

As the sea grasses disappear, so do the fish that attracted people such as Gottshall and Thomas to the area.

The losses, though, have an impact on more than just fishermen — they affect the economy of the entire area.

Natural Resources biological scientist Barbara Hoffman has calculated that an acre of wetlands (mangrove swamp or sea grass) produces a direct fisheries yield — commercial and recreational — of \$1,257 each year.

No one knows the exact number of acres of sea grasses that have disappeared. Biologists are taking inventory of existing grass

beds in the lagoons. Once that is completed, biologists may be able to compare existing beds with earlier aerial photos of the river and estimate the losses.

## Loss of wetlands costly

One study has determined that 3,000 acres, or 30 percent, of sea grasses vanished between St. Lucie Inlet and Satellite Beach, while mosquito-control programs have impounded 6,000 acres of mangrove swamps. Dikes built to foil the breeding of salt marsh mosquitoes have raised water levels and caused unforeseen ecological damage.

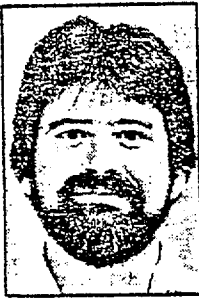
Using Hoffman's calculations, that loss of 9,000 acres of wetlands means a loss of \$11,313,000 in annual income for commercial fishermen, bait and tackle store owners, motel owners and others connected with recreational fishing.

Such bread-and-butter economic realities have motivated commercial clammer Charles Hotcave to report polluters and doggedly follow up the cases to make sure that they are corrected.

The Long Island native migrated south three years ago after pollution closed the clamming waters where he learned his trade, and he is afraid that the Indian River faces the same fate.

"Those waters went from a beautiful, crystal-clear environment to a cesspool," he said, "and I'll tell you, we're not too far behind that here."

Monday: Are there solutions?



White

# Pajic leaves many unanswered questions in bid for gubernatorial nomination

By ROBERT KUNTZ  
Daily News Staff Writer

Surveying the scrap for the Democratic gubernatorial nomination, Steve Pajic sees a battle of ideas in a vacuum of debate.

"There are no great philosophical debates in this campaign," Pajic said Wednesday. "It's a question of who has the leadership ability and who can come in with fresh ideas and new means of problem-solving."

Most candidates are in general agreement on the major issues — such as crime, education, transportation, growth management and the environment — Pajic contends. Among the four candidates with legislative experience, he said, there isn't much to choose from as far as voting records are concerned.

But with 11 years of legislative experience and a record of committee chairmanships, the 1968 Princeton University graduate said he has the stuff of which leaders are made.

On Wednesday Pajic was fresh from a meeting with the Northwest Florida Sheriff's Association, a group that has given its nod to Pajic's candidacy.

As befits a candidate with a law-and-order endorsement, Pajic

said it's time to get tough on crime. "Our whole judicial system needs to be overhauled," he said. "We are sending the wrong message, especially to juveniles and career criminals."

The message he'd like to send is that if you do the crime, you'll do the time — all of the time. And he thinks sentencing guidelines, originally imposed to help achieve that end, have failed.

"I'd like to abolish sentencing guidelines, especially for career criminals," Pajic said. "They were set up because people were sentenced to 15 years and serving three. Well, now people are sentenced to life and serving one and a half."

Pajic said he wants the state to build a system of regional minimum-security jails and then fill them with prisoners now doing time in maximum-security prisons but who don't belong there. Then there would be space in the maximum-security facilities to keep career criminals in jail longer.

"There is no excuse for releasing a criminal back into the streets because there is not enough prison space," Pajic said.

Pajic said he is willing to carry a tough stand on crime to the limit, despite his personal opposition to

the death penalty and his votes against it in the Legislature.

"If I'm elected governor, I would continue to what Gov. (Bob) Graham has done and expeditiously sign death warrants," Pajic said. "I believe it would be my duty as governor to put aside my personal feelings and sign the warrants."

The death penalty isn't the only reality Pajic has indicated he can live with, despite his personal views.

Pajic opposes casino gambling — "more lights, more dancing girls, more organized crime" — but said he intends to "stay away from a debate on the merits" of a state-run lottery.

Nonetheless, he is willing to see such a lottery benefit a public school system that he said needs help.

"The lottery is going to be on the ballot and it is going to pass and when I'm governor I will make sure the money goes to education," Pajic said.

But however it's funded, Pajic said, there needs to be an increase in teachers' salaries.

"Teaching is the key to good schools," Pajic said. "Florida has got to have the best teachers, and that means we're going to have to

pay for them."

Besides a lottery, Pajic said, some of the money for better salaries can come from dropping some of the \$1 billion in exemptions to the state sales tax.

That's an issue the Legislature is grappling with this term, but Pajic isn't there to help. He resigned his House seat in May to run for governor and has criticized his opponents for failing to do likewise.

Pajic is unwilling to describe himself in terms of the liberal-conservative continuum, but a good barometer might be his views on growth management and the environment.

Pajic said the state has too many agencies with too many "low-paid, inexperienced bureaucrats" regulating growth and the environment. The regional planning councils, the departments of Environmental Regulation, Natural Resources and Community Affairs, and the Game and Fresh Water Fish Commission should be consolidated and some of their employees fired, he said.

But he balances that conservative, streamlined-government stance with the statement that, while growth management is a job best left to local governments, it's a job they should be compelled to do.

Pajic will describe himself as a "North Florida Democrat," which he said gives him a better understanding of the Panhandle's

needs than his mostly South Florida opponents have.

And he points out that he's not likely to forget the needs of the Panhandle in general, and Okaloosa County in particular, so long as his sister, Mary Grace Evers, continues to be a Fort Walton Beach resident and an Okaloosa County teacher.

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We're (fishermen) going to have to get involved — now more than ever," Taylor said. "We learned a lot — I'm eager to learn more."

Jan Platt, who is chairman of the Agency on Bay Management, said she has crabbed, fished and shrimped on Tampa Bay. She added she has witnessed a decline in her catches.

"We can have very clean water — but if we don't have the ingredients that are the habitats for fish (seagrasses and mangroves) — the decline is the most alarming fact," Ms. Platt noted.

She recommended pushing for strong regulations on storm-water discharges, as well as further state laws and more staff for regulatory agencies.

"We need to be ever aware of the fact that each piece is an important part of the whole," Ms. Platt added.

The Agency on Bay Management is "an important first step for the bay," Ms. Platt said. "It's to everyone's advantage for the bay to be what we want it to be (economically beneficial for the shipping and fishing industries)."

Fishermen want to pay their own way by buying saltwater fishing licenses, said Larry Hart, who runs a statewide fishing society with 800 members in the bay area alone.

Each Florida fisherman paid \$7 for a saltwater license, about \$14 million to \$35 million could be raised, Hart said.

Robin Lewis of the Agency on Bay Management said the agency is planning to replant seagrasses in Hillsborough Bay sometime this summer.

"It is possible to reverse some of (the damage)," Lewis said.

# Officials Agree: Bay Improving

*The need for continued vigilance was cited during Bay Day '86.*

By Lisa Cunningham

In a repeat of last fall's Boat-a-cade, about 30 Bay area legislators, environmentalists and fishermen gathered in St. Petersburg Saturday to discuss whether Tampa Bay is clean or polluted.

Although no definite conclusions were drawn, most of the people present agreed that the bay is cleaner now than it was about 10 or 15 years ago (in the 1970s).

The "Bay Day '86" symposium — featuring speakers such as Tampa Mayor Bob Martinez; Roger Stewart, director of the Hillsborough County Environmental Protection Commission; County Commissioner Jan Platt and other officials from agencies such as the Department of Natural Resources and the Department of Environmental Regulation — was followed by a cruise from St. Petersburg to Port Manatee, in the lower portion of Tampa Bay.

Ruskin fisherman-turned-environmentalist Gus Muench and his family also attended the morning session and followed the cruising boat in his motorboat.

The session and cruise were sponsored by the Tampa Bay Regional Planning Council, its Agency on Bay Management and the Florida Institute of Oceanography in St. Petersburg (which provided its boat, the R/V Suncoaster).

"I think that all governments that border on this bay need to be concerned," Martinez noted.

Tampa city officials can show their concern by setting aside money for such projects as improving the Bayshore Drive seawall and acquiring property on McKay Bay, south of Adamo Drive, he added.

Stewart said he was concerned that more people did not attend Bay Day. "How can we get to the lay public?" he wondered.

Although Stewart said he used to travel on the bay all the time, he recently toured the bay after a six-year absence.

"What little I saw last Thursday in no way compared with what I used to see 10 or 15 years ago," he said. The water looked much cleaner than during the early 1970s, he added.

He cautioned the environmentalists who might want to begin projects to "restore" the bay. "Nobody restores a system like Tampa Bay — that's a physical impossibility.

"What we do is stop bullying the system — (and start) patching it up, helping it along — put the funds where they're going to do the most good," Stewart suggested.

The EPC has 55 stations in the bay where it has monitored bacteria counts and chemical data for the past 14 years, said Rick Wilkins of the EPC.

The bacteria counts in Hillsborough Bay have usually been the highest, followed by Old Tampa Bay, Tampa Bay itself, and lower Tampa Bay, Wilkins said.

Two additional sewage treatment plants (at Hookers Point and River Oaks) have improved water quality in Hillsborough Bay, he noted.

While Hillsborough Bay is also high in the amount of algae growing in it, phosphate levels have been reduced in the last several years, Wilkins said.

"We're playing catch-up," noted Jacob Stowers, Pinellas County's assistant county administrator. "I believe Pinellas County is a very good example of how you can destroy an estuarine system."

An estuary is an area where fish reproduce and live; many estuaries are protected by seagrasses and mangroves.

Boca Ciega Bay, when it was developed between the 1920s to the 1960s by many subdivisions built on canals, after dredging and filling, had many adverse effects on seagrasses and estuaries, Stowers noted.

"We can't put the habitat back," but agencies such as the Pinellas County Planning Council may stop similar destruction of fish habitats in the future, Stowers said.

Enforcing planning ordinances is one tool to preserve fish life, he added.

The bay seems to be improv-

ing somewhat, said Rick Garrity, the director of the DER's Tampa office. The misconception is that "the bay years ago was a heck of a lot better than it is today."

However, the bay was worse 10 years ago, he added.

Pollution and sewage problems in the bay were recorded as far back as 1887, Garrity said. Now there are more than 60 companies which discharge chemicals and other substances into the bay.

"We have to be very diligent in regulating dischargers," Garrity said.

The Alafia River basin, where Gardinier, Inc. — which holds a temporary operating permit — discharges into the bay, is an important concern, Garrity said. He recommended studies on wasteload allocation on the Alafia and Manatee rivers.

"We need a final solution on what makes the bay tick," Garrity added. "We need an alert regulatory program" to "regulate dischargers extensively."

Pollution in the Alafia River also needs to be addressed, Garrity said. Biological data, as well as chemical and physical studies of the bay, need to be gathered, he added.

Yet many other agency officials present agreed with Garrity that the DER, DNR and EPC could use more funds and scientists, as well as graduate programs at state universities, to carry on their research.

DNR environmental scientist Ken Haddad explained the importance of estuaries to the group.

Seventy percent of Florida's commercial and recreational fish species, such as grouper, snapper, shrimp and mackerel, utilize estuaries as a place for food and shelter, Haddad said.

Although seagrasses and mangroves are important to fish, seagrasses in Tampa Bay were reduced by 80 percent between 1940 and 1980, Haddad noted.

Mangroves were eliminated by a rate of 44 percent during that same time period, he said.

He contrasted Tampa Bay with Charlotte Harbor, which is still relatively untouched by urban development. Charlotte Harbor represents the only area of the state where the

seagrass and mangrove numbers were not reduced — in fact, 10 percent more mangroves have been added, Haddad said.

Commercial fish catches in Tampa Bay have thus been a slight down trend, with peaks and valleys over the past 15 to 20 years, Haddad noted.

Haddad lamented the fact that he has no biological data on how fish are actually affected by the seagrass and mangrove loss in the bay. "There's a relationship — we can't quantify it."

Long-term programs "to understand what we're doing to Tampa Bay" are needed, Haddad said.

The primary problem is educating the public on the need for these programs, he added. The recent DNR survey shows most Floridians have no idea what an estuary is, he said.

Biologically and chemically, Tampa Bay is "much worse" than 100 years ago," noted Carl Goodwin, a U.S. Geological Survey scientist.

However, Tampa Bay has also experienced a period of "tremendous, positive growth," Goodwin said.

Goodwin said he studied the amount of fine sediment which settles on the bottom of Tampa Bay. If all the sediment that accumulates on the bottom of Hillsborough Bay in one year

time was dried out, it would weigh one million tons, Goodwin said.

Boat activity, dredge and pile operations, and even docks at piers can all stir up sediment, Goodwin explained. Sediment makes the bay look murky, he added.

"There's a lot of people that don't realize there's a problem because they haven't been here very long," said Mark Taylor, the president of the statewide fishing society.

"I think as fishermen we've witnessed the decline in some of our fisheries," Taylor added.

He agreed with Goodwin that sediment has adverse effects. "This stuff will burn your skin and be bad (that oil-skinned coats must be worn by some fishermen)."

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Bradenton Herald  
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# Man-made wetlands concern Manasota 88

JOHN ALLARD  
Herald Staff Writer

Environmentalists are concerned that the state's consideration of developers' plans to recreate wetlands to compensate for ones they fill in will lead to approval of more fill permits for salt marshes and other wetlands.

A case in point is the Department of Environmental Regulation's initial decision to approve a permit that would have allowed developer Wilbur Boyd to fill in 17 acres of wetlands for a golf course at his Riverbay project in Northwest Bradenton.

Manasota 88, an influential environmental group, appealed the ruling to a state administrative hearing officer, who probably won't issue a ruling on the matter for several weeks.

DER's initial approval of Boyd's permit request was due in part to his promise to create a 1½-acre artificial salt marsh to replace some of the wetlands he fills in,

said Anthony Cleveland, a DER attorney.

Under the 1984 Henderson Wetlands Act, mitigation plans have to be considered by DER when it looks at requests to fill in wetlands, Cleveland said.

DER's consideration of mitigation in permit decisions has angered environmentalists who argue that it doesn't work in most cases.

No one has ever tried to recreate a salt marsh in Florida, said Manasota 88 Chairwoman Gloria Rains.

By granting fill permits to developers who have offered to create some artificial wetlands, DER is risking the loss of valuable marine habitats with no guarantee that they will ever be replaced, Rains said.

Wetlands are important breeding and feeding grounds for fish and wading birds.

A study of wetlands in the Tampa Bay region, including the north

part of the county, showed that a large percentage of wetlands had been lost. The study was conducted in 1980 by Robin Lewis, president of Mangrove Systems Inc., a Tampa firm that specializes in recreating wetlands.

That study showed that 81 percent of seagrass lands and 44 percent of the mangroves and salt marshes were lost between 1940 and 1980, said Barbara Hoffman, a marine biologist with the state Department of Natural Resources' research laboratory in St. Petersburg. She said 11,000 acres of

mangroves and salt marshes were lost, while 61,965 acres of seagrass were lost.

"Tampa Bay has really been upset as far as marine habitats are concerned," Hoffman said.

In response to complaints from environmentalists, DER has attempted to come up with a rule to govern the application of mitigation to fill permit cases, said Suzanne Walker, chief of the DER's bureau of permitting.

Under the proposal, developers would have to create two acres of

artificial wetlands for every acre they fill in, to allow sufficient time for the new wetlands to begin to function, Walker said.

Developers also would have to assume financial responsibility for mitigation projects that cost over \$20,000, Walker said. They would have to post bonds or some other means of assuring that they build artificial wetlands, she said.

But environmentalists say the proposed rule won't prevent enough developers from filling in more wetlands.

"What they (DER officials) are really trying to do is accommodate the developers, while maintaining the environmental stance," Rains said.

But adoption of the rule would not be an open invitation for developers to fill in wetlands, Walker said. That rule would simply give DER some criteria to use when it considers mitigation as part of a fill permit application, she said.

A draft of the mitigation rule should be finished by the end of the month, Walker said.

# storm-water runoff called next big hurdle

• Last of a series

By BOOTH GUNTER  
Tribune Staff Writer

TAMPA — It starts with fertilizer on the lawn, a dead animal on the road or the muck that seeps from the bottom of a dumpster.

Add rain and it becomes storm-water runoff, killer of fish and other marine life in Tampa Bay.

Environmentalists call it non-point pollution — the kind that can't be traced to a specific source — and say it is the next major hurdle in cleaning up the bay.

Agricultural pollution plays a part, of course, but in the past decade, there have been major gains in treating those wastes.

And, warns Michael Perry, an administrator with the Agency on Bay Management, unless the 20-year battle to improve water quality is won, Tampa Bay, which has been the area's biggest asset, could become a major liability.

Hanging in the balance is a multimillion-dollar commercial-fishing industry and the area's chief recreational and tourist attraction.

"I have been here 56 years, and I've seen this bay go slap to hell," said Robert Richards, a commercial fisherman. "If the pollution gets much worse, what we catch won't be fit for human consumption, and that's an awful thing to say about the bay."

Storm-water runoff is the catch phrase to describe the way the scraps of everyday life are washed, untreated, into the bay.

As the area around the bay becomes more urban and ground is covered with buildings and parking lots, attempts to clean up the bay will focus on old drainage systems and developments engineered before the phrase non-point pollution found its way into the environmental vernacular.

Controlling the runoff will require massive expenditures by government and private industry, environmental officials say, and many are wondering how much the public is willing to pay. Estimates for updating drainage systems in the Tampa Bay area exceed \$1 billion.

"It's going to boil down to: Are we willing to pay the price?" said Gary Kuhl, executive director of the Southwest Florida Water Management District, the agency that would be in charge of controlling storm-water runoff in Tampa Bay under legislation passed Wednesday by a House committee.

"It is a problem that, at this point, does not have a solution," said John Betz, a University of South Florida marine biologist who has been working with legislators to draft bills to help clean up the water in Tampa Bay.

The Surface Water Improvement and Management (SWIM) bill would require the water management district, known locally as Swiftmud, to complete a major study of water quality in Tampa Bay by February 1989, and develop a plan to control pollution from storm water and waste water treatment plants.

"It's going to be a problem that we're going to have to come up with solutions for, and they won't be easy solutions," Kuhl said. "Most any study you see done by well-qualified people says that, nationwide, (storm-water runoff) is our biggest problem now."

Developers say the SWIM bill could force them to add new drainage systems to existing structures as they are redeveloped. The cost would be enormous, they say.

"It's hard to tell whether we're talking tens of millions or hundreds of millions until we see the effects of the bill statewide," said Ron Weaver, an attorney representing the National Association of Industrial and Office Parks.

Betz said it is a mind-boggling proposition to control urban and agricultural runoff from the 2,200 square miles of land that drains into Tampa Bay, Florida's largest estuary. It will become even more pressing as the population in the three counties surrounding the bay tops the 2 million mark by the turn of the century.

The pollution comes from a multitude of sources, many of which seem harmless. "Anything you might dump around your house, the remains of a can of gasoline you had left over, brake fluid, radiator fluid, lubricants, kerosene, the feces of animals, dead animals, spilled

food," Betz said.

During stormy weather, the first inch of rainfall picks up about 90 percent of the pollutants on the ground or street, and much of that eventually goes into the bay through drainage systems that were designed before scientists recognized the problem, Betz said.

"That first inch can have a concentration of stuff equivalent to raw sewage," Betz said.

Not only does storm water put toxic substances in the water, but it also adds nutrients, such as nitrogen, phosphate and organic matter, that cause rapid algae growth. This algae eventually kills fish by using up oxygen in the water as it decomposes.

Studies have shown that the upper parts of Tampa Bay, which receive most of the pollution, have extremely high concentrations of nutrients in bottom sediments, a product of decades of pollution and the bay's naturally slow circulation.

Poor water quality in the bay has been blamed for the loss of thousands of acres of marine habitat, including sea grasses, which provide food and hiding places for juvenile fish and shrimp as they mature. Studies indicate that 81 percent of Tampa Bay's original 76,500 acres of sea grasses have disappeared. Some sea grass was destroyed by dredging, but the bulk of it disappeared "for no mechanical reason," said Kenneth Haddad, a marine biologist studying sea-grass loss for the Department of Natural Resources.

The biggest problem with storm water is not with new developments because most of them are required to have storm-water systems. The problem is with development that took place before the regulations were enacted in 1982.

Most storm-water runoff systems consist of retention ponds, which allow pollutants to settle before the water is piped out to traditional drainage routes, Kuhl said.

Installing storm-water systems is expensive enough in new developments, but going back to add them to developed areas becomes prohibitive in some cases, Betz said.

Weaver said current drainage regulations are strong enough. He said the SWIM bill, which would require a master storm-water plan for Tampa Bay, would place another, unnecessary tier of regulation on developers.

But Kuhl said the bill would not create more regulation for developers, who now must get storm-water permits from the Water Management District's board.

"What it does is ask the permitting agency to ensure it is incorpo-

mendous cost for both public and private interests.

"I think the technology is there; it's the cost and physical ability to go in where you already have a city and change the drainage" that will be a challenge, he said.

rating the portions of the plan to clean up Tampa Bay into the existing permitting process," he said. "It will not be another formal level of permitting."

Kuhl said changing existing drainage systems would be a tre-

# Tide's turning in fight to revive bay

First in a series

By BOOTH GUNTER  
Tribune Staff Writer

TAMPA  
Tribune  
4/22/87

TAMPA — Out on the tip of H. L. Hunt's Point, at a place created by man's desire to make a ship channel, Roger Stewart stood ankle deep in memories.

"There's an awful lot of marine life out there now," he said. "Every little piece of seaweed you pull out of there has got something living on it."

It's much different from the water he studied as a graduate student at the University of South Florida in the late 1960s.

The bay was dying.

At this very spot, you could smell the fetid odor of raw human waste dumped into Florida's largest estuary from Tampa's overloaded sewage treatment plant.

Toxic wastes from factories flowed freely.

Mangrove forests became condominiums.

Sea grass disappeared.

So did the fish.

And then there was the dredging. Scientists are still assessing the damage it caused.

That was all before Stewart and a core of other environmentalists began to study the bay and to take on the polluters.

The bay hasn't fully recovered from the decades of dredging and pollution, but the signs are good, scientists say.

Water quality, monitored since 1972, has improved considerably. And there are signs that sea grasses, which help form the base of the marine food chain, are making a comeback, Stewart says.

Many bay activists are cautious about the gains in water quality, saying the pressures of greater urbanization in the Tampa Bay area could cause a reversal in the trends.

But Stewart, director of the Hillsborough County Environmental Protection Commission, is optimistic about the bay's chances.

Against a backdrop of power and phosphate plants, he pulled a rock from the water.

"You go out here and pick up a rock or something, you'll find it's encrusted with all kinds of living things," he said.

"There are nice, fat, happy little oysters living right here in the ship channel. The bay's not dead by any means. If the water were lousy, you'd find dead things."

Scientists say they are only now beginning to understand the long-

term effects of the pollution and dredging on the marine life.

While the harm will be felt for generations, some of the underlying problems have been corrected, Stewart and other environmentalists say. Tampa has a new, advanced sewage treatment plant; industrial waste dumping is restricted; marshes are no longer filled in to create land for houses.

But the fast-track development of the Bay area worries environmentalists. Population in Hillsborough, Pinellas and Manatee counties, which surround the bay, is expected to explode from 1.7 million to 2.08 million in the next 13 years, bringing new pressures on the bay.

New threats to the bay continue to develop.

Recently, the Gardiner Inc. phosphate plant, the largest on the bay, dumped almost 14 million gallons of untreated acid into the water after heavy rains. The EPC is assessing the damage.

And Tampa Electric Co. is lobbying in Tallahassee to keep avenues open for construction of a power-generating plant at the Cockroach Bay aquatic preserve. The power company says the plant is needed to accommodate growth. Environmentalists say the plant would upset the fragile marine habitat left in Tampa Bay.

Meanwhile, the House Natural Resources Committee is expected to vote today on the Surface Water Improvement and Management (SWIM) bill, described as the most significant environmental legislation in years. On Tuesday, both the House and Senate observed Tampa Bay Day.

Sponsored by Rep. Sid Martin, D-Hawthorne, the SWIM bill would make the state's five water management district boards responsible for protecting and restoring surface waters all over Florida.

In the Tampa Bay area, the Southwest Florida Water Management District, known as Swiftmud, would take the lead in overseeing research and cleanup programs. It would mean a small increase in property taxes to provide matching money for state grants.

The Tampa Bay portion of the bill calls for a \$1.8 million state appropriation. A state trust fund would be established to pay for cleanup programs in the years ahead.

While scientists and environmentalists believe they know the bay's major problems, there is considerable disagreement about how to fix them and how much more re-

search remains to be done before spending money on costly cleanup measures. Estimates for the total cleanup reach into the billions.

Stewart, 61, the once-radical guru of the cleanup movement, believes the bay can heal itself if the pollution and dredging are controlled. The dredging is gone, except for maintenance of the ship channels; and major inroads have been made in controlling municipal and industrial wastes.

"Personally, I have a great deal of faith in Mother Nature," he said. "I think the best way to fight ecological battles is to remove the burden."

To make his point, he shows aerial photographs, which he said show sea grass returning naturally to once-barren bay bottom.

Restoration of the habitat, advocated by many environmentalists, is a costly venture and may not even work, Stewart said.

Many fish species, including shrimp, use the plant life in the shallow waters of the bay to feed and avoid larger fish while growing up.

Once damaged, the vegetation is slow to return. The decline of these habitats has been blamed for reduced fish populations. Mangrove trees prevent shoreline erosion, filter water and provide nursery and feeding grounds necessary for marine life.

Kenneth Haddad, a marine biologist at the Department of Natural Resources' Marine Research Laboratory in St. Petersburg, is studying the loss of sea grass. The improvement in water quality has not significantly spurred the comeback of sea grass and other fish habitat. Sea grass planting is still in the trial stages and research remains a priority.

Robin Lewis, a marine biologist and private consultant who along with Stewart and others was active in the bay cleanup movement that began in the late 1960s, agrees the bay needs more study. He and another scientists are compiling all of the scientific research on the bay into one document.

"In that document, we point out that there are many gaps in what we know," he said. "We know a lot about little pieces of the bay. We don't know a lot about the bay as a whole."

He likens the bay to a living, breathing body, in which all systems depend on one another. Damage to one plant or fish species begets damage to another.

"The first thing you do is, you

# Clean air assures us our breath for life

Clean Air Week is April 26 to May 2. Most air pollution is man-made, and motor vehicles are the biggest contributors. Poorly adjusted engines and mistreated or disconnected catalytic converters can cause seven times as much pollution as a well-tuned engine and functioning converter.

Ozone, a key constituent of smog, forms when unburned hydrocarbons from poorly-tuned gasoline engines reacts in sunlight with nitrogen oxides from exhaust. The nation has 76 air pollution control areas in which ozone levels exceed the federal health standard. Seven are in Florida.

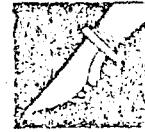
Unfortunately, a myth exists among backyard mechanics that money can be saved using leaded fuel in a car equipped with a converter or that altering some of the settings on the exhaust control system saves fuel. Joint Department of Environmental Regulation and the Environmental Protection Agency's random inspection of autos and light trucks in Tampa in 1984 revealed that 38 percent of their exhaust systems had undergone tampering. This was the highest tampering rate in the nation. Miami had the second highest rate. Between 20 percent and 25 percent of the vehicles had been misfueled.

Each year states must submit plans to be approved by the EPA that outline efforts to clean up the state's air and water. On April 7, the EPA administrator sent letters to governors of all states with areas which did not meet ozone standards, giving them until Dec. 31 to meet standards or suffer the loss of federal highway or sewer funds. Florida could comply with federal regulations and meet the standards by implementing annual auto exhaust control inspection.

This inspection would rapidly weed out those cars which have had exhaust control tampering or misfueling. A trained mechanic can visually inspect nine parts of the engine and a simple tail pipe test can detect misfueling. It should not take more than a minute to do. If 20 percent of Florida's vehicles are emitting seven times the normal pollution, they are contributing more pollution than all the other cars in Florida, and are responsible for Florida's failure to achieve the air quality we all want.

Eventually it may be necessary to require vapor-recovery nozzles at filling stations.

During the first week of Febru-



MY VIEW  
Patty DeTar

ary, the U.S. Senate Subcommittee on Environmental Pollution heard testimony from three of the nation's leading doctors. They said that next to cigarette smoking, breathing acid particles or fine acidic droplets is the greatest cause of lung disease. Florida is the 10th worst state in the nation for the amount of sulfur dioxide; most is produced by utilities. Exposure to acid deposition is directly related to the amount of sulfur oxides being emitted in any region. Now that we know our health is being affected, we must join in the nation's effort to enact a strong acid rain bill. The technology is already here and costs have decreased greatly.

Acid rain in forests has recently been linked to disappearance of the fine hairs on tree roots as well as the killing of beneficial soil microorganisms that help roots absorb nutrients. The result is slower growth.

Ozone, on the other hand, has a more immediate effect on the green parts of trees by interfering with photosynthesis. Both ozone and acid rain are harmful to the lungs. The EPA administrator is considering imposing both stricter ozone standards and stricter sulfur dioxide emission standards, since health effects have now been noticed in human subjects at lower levels of both pollutants than were previously thought to occur. This would make it even harder for Florida to meet federal air pollution health standards and may mandate sulfur dioxide controls on the worst polluting utilities and auto exhaust inspection for the entire state.

The DER along with the American Lung Association is sponsoring a free auto-exhaust check May 2, 10 a.m. - 4 p.m. near Sears at the Governor's Square Mall. During Clean Air Week, the Lung Association will also sponsor air pollution reports on the CBS and ABC local news stations. The report will include information on the ozone levels.

Patty DeTar is chairman of the Air Quality Committee of the American Lung Association of Florida.

out what those particular problems are, and come up with some solutions based on science," Lewis said. "The truth is, we have to spend a couple of years examining the problems and only then can we

spend the money effectively.

"We are never going to have enough money to do everything. Even that assumption, how do you spend the money? The answer is, we don't know."

Stewart's faith remains firmly rooted in the natural resiliency of the bay. But he is ever vigilant of the possibility that the ways of the past will return. He uses words like a torrent when describing the dredge-and-fill operations of the pre-1970s days. "Over my dead body will anything like that happen in Tampa Bay" again.

At Hooker's Point, man's damage to the bay is still most evident. Concrete and steel rubble, rusted cans, an old volleyball and other garbage litter the shoreline where mangroves have sprung up since the land was created by dredge spoils.

Away from the shoreline, Stewart spies two steel, 55-gallon drums. Casually, he jams a finger into an opening in one. It comes out black and gooey.

That says 'olive oil' on it, but it's old, used motor oil. Somebody's lumped some old, used motor oil in here. Inevitably, it's going to get out of the bay."

He shook his head. Some things haven't changed.

TAMPA TRIBUNE 4/22/87

## Panel backs river drive

INVERNESS — Citrus County commissioners expanded their support Tuesday of a move to have the Withlacoochee River designated an Outstanding Florida Water.

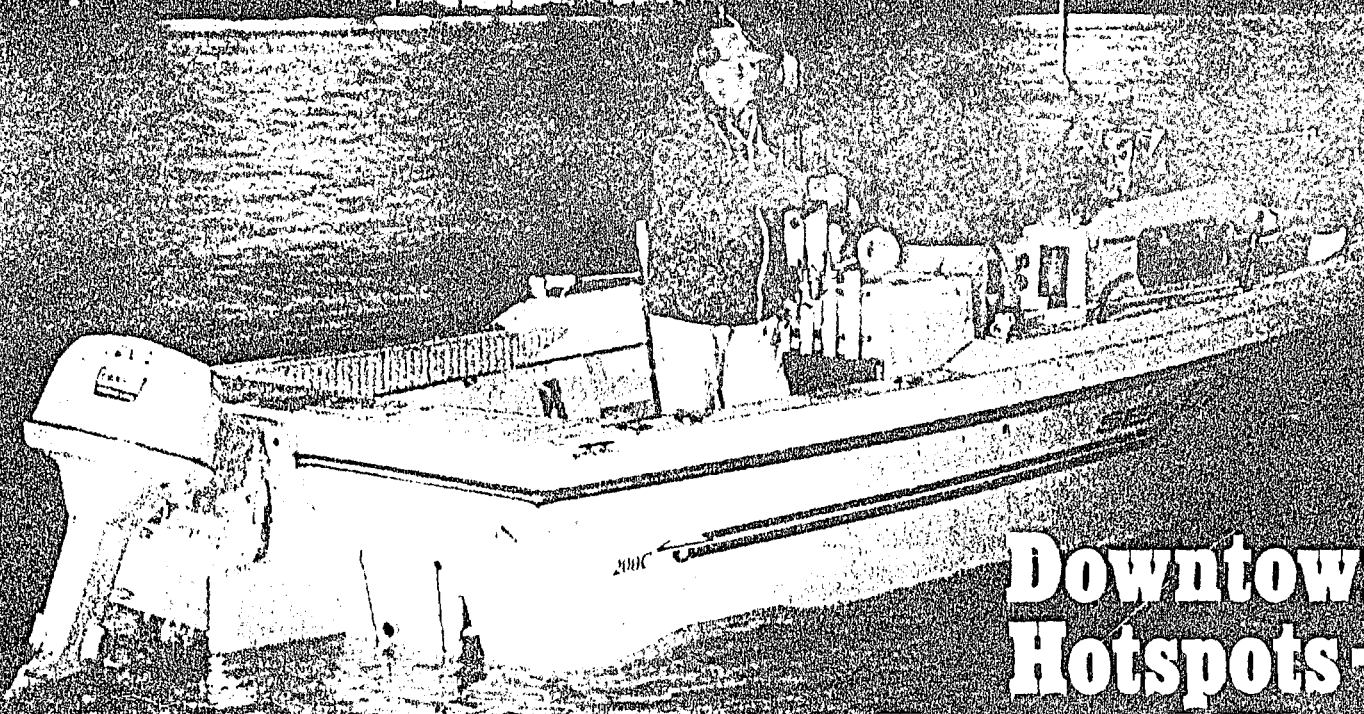
The commissioners voted to back the drive to protect a stretch of the river about 12 miles long from the western end of Lake Rousseau to the Gulf of Mexico.

Citrus commissioners already had agreed to support the effort for about 150 miles of the river from its headwaters in the Green Swamp to the eastern end of Lake Rousseau. The lake was not included because its water does not meet state standards for the outstanding designation.

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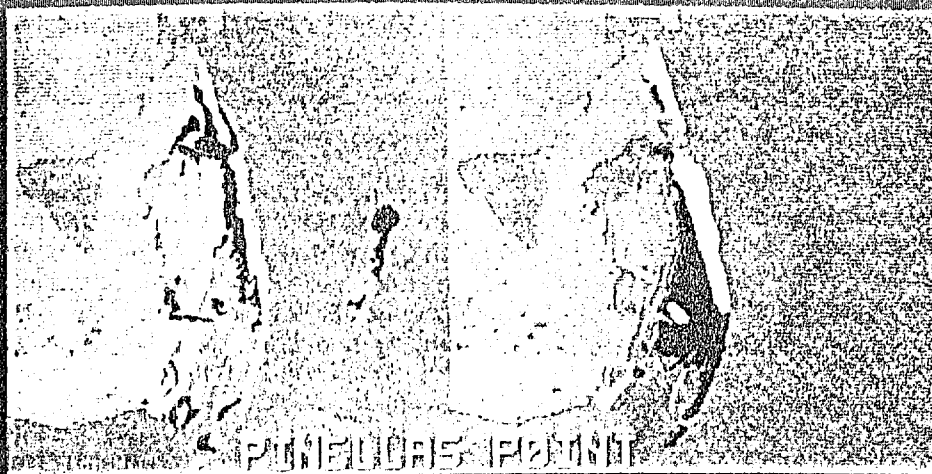
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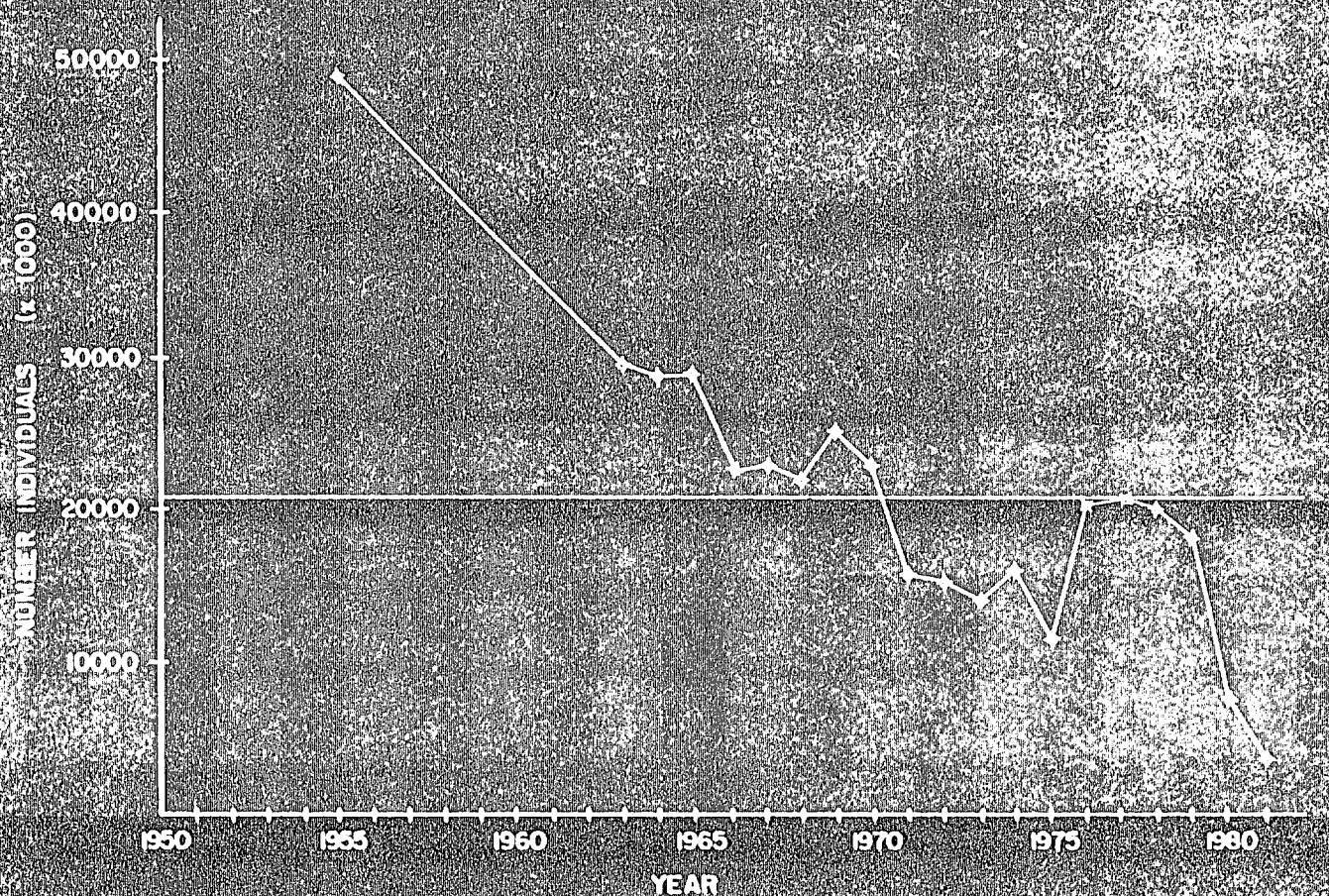


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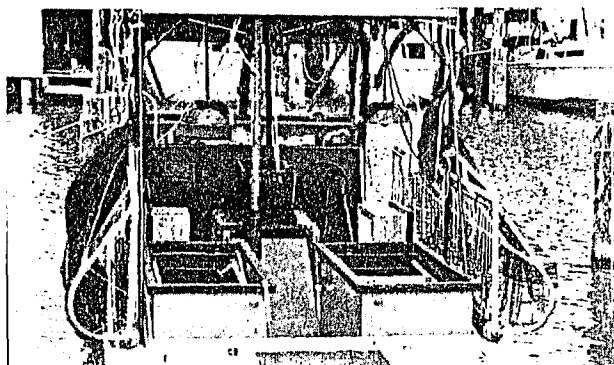
TAMPA BAY: BAIT SHRIMP

SPECIAL SERIES

THE SHRIMP CONNECTION:

# Trawling for Trouble

*Destruction of Gulf and bay bottom, a side effect of shrimping, is a burning issue in Florida.*



By MARK WEINTZ

*Editor's Note: Shrimp are a vital link in the marine food chain, directly affecting the quality of our fisheries. This is the third article in an in-depth series examining the handling, or mishandling, of our vital shrimp stocks. The first two articles covered indications that we are allowing an overharvest of shrimp, causing a basic decline in marine life, and that officials have been lax in requiring simple devices that will save thousands of turtles and megatons of juvenile fish. This month covers the question of bottom destruction by shrimpers.*

**F**ar out in the Gulf of Mexico are barren stretches of bottom—marine deserts which sometimes support green stubble if anything at all. Many of these large areas display strange scars in the sand, as if something heavy had been dragged through.

Those who discover these voids usually move on if they are searching for fish or underwater sights. But sometimes, awed at the sudden sterility, a diver lingers to contemplate the mystery.

To some, such undersea wastelands are no mystery at all. They seem obviously to be the result of shrimp trawls being

dragged across the ocean floor. Commercial shrimpers, however, say their nets are not the cause of the damage.

"Trawl damage," is an issue that has been smoldering for years, but which lately has burst into flames. In the wake of escalating declines in marine habitats and fish populations, testimony from "expert witnesses," most of whom are shrimpers, is beginning to be heard before various fisheries management councils.

The controversy promises to be a complex one because:

- There is a lack of scientific data on trawl impact.
- Little money is allocated to conduct the necessary studies.
- There is a misunderstanding about the different trawl types and how they work.
- Waterside development and its documented negative impact on aquatic resources continues to escalate, making it difficult to keep the trawl issue in perspective.

Declining shrimp and fish populations often throw policy makers into the undesirable posture of "crisis management" and a major problem with managing a crisis is that vital, long-term factors can be overlooked in the stampede to preserve stocks.

A good example is the spotted seatrout. Grassy habitats and ample shrimp stocks are vital to trout. Research has shown

a sharp decline in trout catches in Tampa Bay.

"Since 1952, Tampa Bay has lost 64 per cent of its sea grasses," said Kenneth Haddad, marine biologist with the Florida Bureau of Marine Research in St. Petersburg, adding that an estimated 80 per cent of this vital grass has disappeared since 1900.

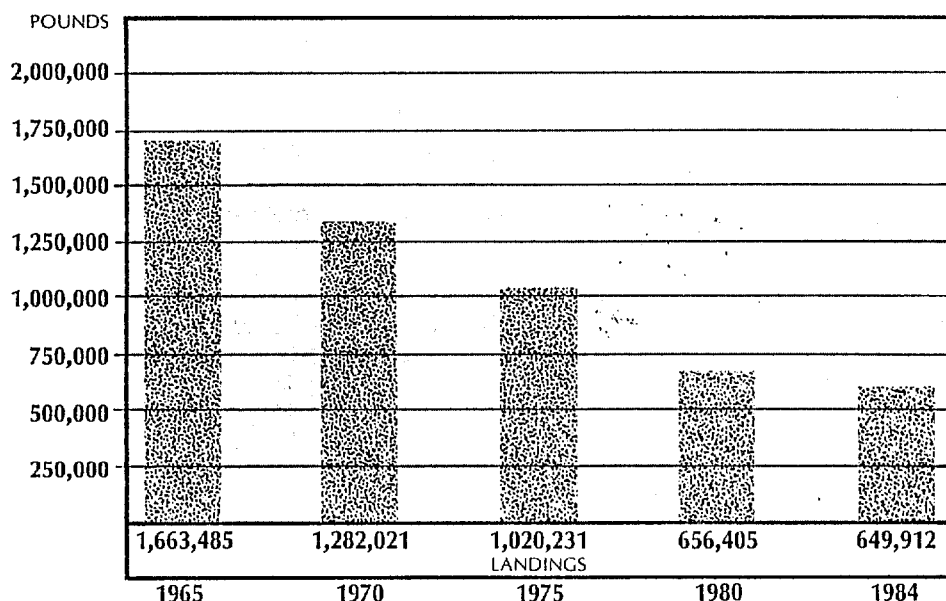
Seagrass losses—by no means limited to Tampa Bay—are linked to a serious decline in both shrimp landings and trout catches. In the mid-50s, Tampa Bay bait shrimpers brought in some 50 million shrimp, according to Haddad. By 1981 only three million were caught and since the bare-bones studies done thus far don't include fishing effort, the findings are not exact.

Nevertheless, the apparent magnitude of the losses is making the Tampa Bay situation a hot topic on the West Coast. And the connection between habitat, shrimp populations and shrimpers is becoming even more of an issue because the bait shrimpers, of course, are now concentrating all their efforts on the limited areas where seagrasses remain, Haddad added.

**M**any states have ongoing programs that have for decades monitored the status of vital fisheries. But in Florida, research programs are jump-started annually and are often geared to address a particular crisis. An example is a small, one-year

## Kill the Grass . . . and Kill the Shrimp

Here's a rundown of how commercial bait shrimp landings in Florida have declined over the years:



study that just began on bait shrimping in Tampa Bay.

Even as shrimpers converge on virtually every patch of grass in Tampa Bay, the Florida Marine Fisheries Commission has begun a series of workshops designed to investigate shrimping. But since the MFC

has little money with which to conduct research, the workshops will primarily revolve around the scanty studies that have been done by the DNR's Bureau of Marine Research and the testimony of the aforementioned commercial "witnesses."

Until last year, the state legislature and

county governments had jurisdiction over the issue of destruction of marine habitats by shrimp trawlers. For its part, the legislature relied largely on the same experts that will be appearing before the MFC to speak on trawl damage.

After being given authority over shrimping last year, the MFC hired a shrimp biologist—a position the Bureau of Marine Research never did have—but shrimping studies promise to be expensive and time-consuming. Any valid research must cover different types of nets, different types of bottoms, shrimping grounds within the state and the different types of shrimpers presently operating in Florida waters.

Though Tampa Bay is targeted as a top-priority area nobody can really prove who is to blame—or to what extent blame should be shared—for the loss of seagrasses, shrimp and trout. Development, sewage, Florida's pro-growth policies and waterfront construction, are all factors that have to be taken into account when trying to assess trawl damage.

"There has been no research that has been completed, or that is even ongoing, into what has caused the problem," says Haddad.

A basic question to be resolved is simply "Do trawls damage the bottom?" The answer depends on who is answering it.

"Yes and no," says Bob Jones, executive director of the Southeastern Fisheries Association, whose members represent a broad spectrum of commercial fishing interests, including shrimping. "One storm, or a Northeaster with enough wind to move sediment and everything around on the bottom can do more damage than shrimp boats can over a long period of time. You cannot make a blanket statement such as 'they are tearing up all the bottom.'"

Bob Mahood, executive director of the South Atlantic Fisheries Management Council, which will co-regulate Florida's Atlantic waters with the state when both organizations get a shrimp management plan finalized, replies, "It's debatable. There have never been any definitive studies that I am aware of, as far as shrimp trawls go, that have shown destruction of the bottom. The argument on one side is that the trawls are kind of like a plow and you have to cultivate the bottom to make it productive. The other side says the trawls tear up everything on the bottom and destroy it."

"There is a lot of reason to think that trawls may destroy a lot of bottom grasses and sponges," says Alex Jernigan, chairman of the Florida Conservation Association and a member of the Gulf of Mexico Fishery Management Council. "If you go aboard a shrimp trawler in the southern Gulf, you'll see a lot of sponges and bottom formations that have been scraped up off the bottom. How permanent that dam-

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age is, I don't know."

"Trawl damage is a part of shrimping," said Dr. William Fox, Florida's Marine Fisheries Commission (MFC) chairman. "There is concern about bay shrimpers and inshore shrimpers who use otter trawls and dig up the grass beds." How substantial the problem is won't be known until after the MFC's workshops are completed, Fox noted.

The types of trawls used are certainly part of the issue. Otter trawls are large nets held open by wooden doors and are generally used by "food shrimpers" in deeper water. The doors, the chains that hold the leading edge of the net down and the net itself can all scrape and scar the bottom.

The roller trawl, a different type, is most often used by bait shrimpers who work the seagrass areas of shallow bays. Instead of plowing the bottom, as an otter trawl is likely to do, the rollers on this net are designed to allow the net to roll over the grasses without tearing them up.

Shrimpers, and some researchers and fishery managers, explain that the heavy, bottom-dragging otter trawls are "used in deep water where there are no grass beds." However, a closer look indicates there are some flaws in that long-standing observation.

"In some areas of the Gulf," says MFC executive director Connor Davis, "repeated use of trawls is knocking down all the hard-bottom structure and sea fans. This may be reducing the habitat's ability to support grouper and snapper stocks. But there's not a lot of hard information available."

And even though otter trawls are designed for deep, open water, current regulations leave the choice of where to work these rigs up to the individual shrimper.

"Hell, they come right into 10 or 12 feet of water and they clean the bottom with those trawls," said Duncan MacRae, owner of MacRae's Bait House on the Homosassa River located in the Big Bend area of the Florida Gulf Coast. "I think the commercial part of shrimping (otter trawls) should be moved farther offshore."

The MFC's Fox said the problems of otter trawls digging up grass in shallow water will be reviewed and when the shrimp management plan is taken to the Governor and Cabinet at the end of the year, could contain restrictions on the kinds of gear shrimpers use.

Outside state waters (meaning beyond nine nautical miles in the Gulf) federal jurisdiction begins. Here, the water is generally too deep for sea grasses, says Wayne Swingle, executive director of the Gulf Council. The byword, however, is "generally." In some places, sea grasses do grow because the clear Gulf waters allow sunlight to penetrate to the bottom. And in

other areas, there are sea fans and hard habitats of the kind that concern Jernigan and other critics.

One fact remains clear. Right now, neither the state nor the federal government is protecting the bottom from trawl damage. Another fact that is indisputable is that most of the sea grasses lie in state waters and these habitats are vital to healthy stocks of trout, shrimp, scallops and scores of other species of marine life.

And while grass and habitat destruction are most often associated with otter trawls, there are also problems with roller trawls.

"Basically, the idea of rollers is good," says Homosassa's MacRae, who has been a commercial and recreational shrimper all his life. "They're perfect if they work, but a lot of shrimpers use extremely heavy trawls with small rollers that just bury themselves in the sand."

MacRae says the grass beds from Homosassa northward are vanishing, and while he calls bait and table shrimping a "necessary evil," he says larger rollers on the bigger trawls would help protect the habitat.

Yet another problem with bait shrimpers is "black market" shrimping. Even though, by law, a bait shrimper is required to keep his catch alive, he may sometimes haul up a load that was killed in the net. Shrimp are wanted alive or dead at the dock and some "bait shrimp" are being sold illegally to seafood wholesalers as "food shrimp," a practice state employees note does happen in "some places at some times."

Haddad has begun a study of bait shrimping in Tampa Bay and the initial findings—using two roller trawls and an outboard-powered boat to pull them—indicates that the nets rolled over the grass without "mowing it." But, says Haddad, in order for the study to be truly accurate, it should encompass shrimping gear more in line with what commercial bait shrimpers commonly use.

And, while study is just beginning in shallow-water habitats, nothing is being done on the large offshore grass beds off the Big Bend coast.

Yet another angle of bait shrimping is that it is conducted on nursery grounds. It is well-known that bait shrimpers catch quantities of juvenile fish—including baby seatrout.

"We recognize there is some damage to some habitat as a result of bait shrimping," said Charles Futch, assistant director of the Division of Marine Resources. "You know that shrimp is the most popular bait among fishermen and I think there would be a lot less fishing success if this product were unavailable. So it becomes a tradeoff."

One of the few research studies of bait



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## TRAWLING continued

shrimping that has been completed was carried out on Biscayne Bay several years ago by the Florida Sea Grant College.

"They had a hard time documenting any substantial long-term damage to the habitat," said Futch. The findings indicated that the catch has remained stable from 1971 to 1983 and suggested that the bait shrimp fishery did not significantly affect the habitat's ability to function as a shrimp nursery.

This study, however, contradicts itself when it claims that Biscayne Bay is not a nursery area and that adult shrimp populations swim into the Bay from other places. Making the study even more suspect are the comments of John Stevely, a Sea Grant extension agent. Though not a party to the research project, he said "I wouldn't stake my professional reputation on it. I don't think any of them [the researchers] would."

"They went out and collected some information that I think is fairly reasonable but, if you look at their statistics, there could be some differences in fishing practices that could throw it off," said Stevely.

Despite Stevely's reservations, the Biscayne Bay study is frequently cited by some marine experts as evidence that bait shrimping does not harm the habitat.

The MFC's Davis, who is familiar with the Biscayne Bay study, wonders if the catch of trout in trawls affects the abun-

dance of fish reaching larger, catchable size. Though conceding that the Biscayne Bay study indicated that damage to the trout stocks did not appear to be "all that terrible," Davis says, "Other bait shrimp fisheries in other areas might be totally different. Every bay is totally different. And you do not want to make a blanket assumption that everything is hunky-dory just because one study in one place said it was all right."

The commercial shrimp industry is regulated in Florida the same way it was two decades ago when the fleet was much smaller and its ability to impact shrimp, fish and habitats was correspondingly less.

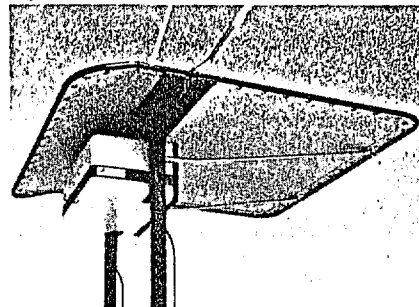
**N**ets are by no means all of the problem, however.

"We had some beautiful virgin country on this coast," said MacRae, "Then all these people moved in and had to shape it, mold it, re-canal it and change the direction of the water. They never cared what damage it did. Now the damage is showing up."

One indicator of the damage is a green slime nicknamed "gumbo" that has begun rolling out of the canals and into the Gulf where it smothers the rocky bottom.

Habitat loss isn't limited to the area of Homosassa. It's a statewide problem. Working with satellite photos and com-

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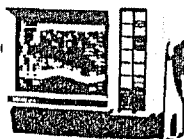
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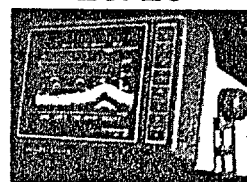


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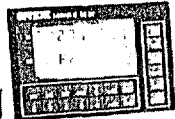
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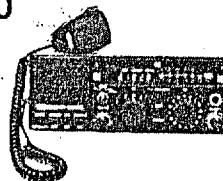


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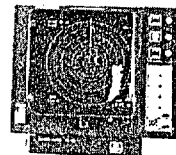
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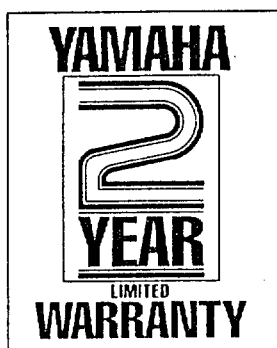
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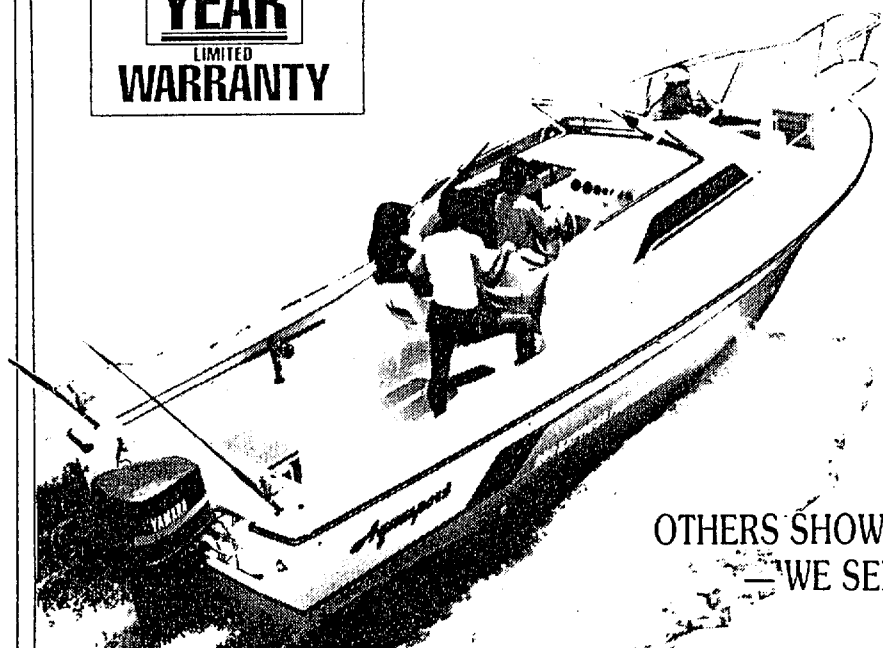
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## TRAWLING continued

puter-enhanced aerial photographs, Haddad and marine biologist Barbara A. Hoffman have been mapping habitat declines in specific Florida waters.

"In Charlotte Harbor we have seen a loss of approximately 25 per cent (of seagrasses)," said Haddad, adding that Charlotte Harbor is one of the state's best-preserved areas. Findings such as this have begun to generate interest—and research money—to determine the cause—and, hopefully, to recommend solutions.

How to pay for this research is yet to be determined. Very little of the billions of dollars generated yearly by Florida's recreational and commercial fishing industries finds its way into research programs.

Though almost everybody agrees that Florida has steadily been losing marine habitat—and probably shrimp production capacity—for a long time, fishery managers can only address a portion of the problem. Their jurisdiction does not extend to growth management, pollution or development.

Trawl damage, however, is a part of the problem they could address.

"Yeah, they cleaned the bottom with those trawls," says Homosassa's MacRae. "I don't know whether the bait boats did it or the commercials did it. Maybe fouled-up rollers did it. The commercials use chain on the bottom. They tear up your grouper rocks and vegetation and everything else with those otter trawls. They have ruined about all the coral on this coast. They flattened it."

Jones, the perpetual advocate of the commercial fishermen, noted that the trawlers try to stay away from outcroppings of rocks and "there may be areas that have certain types of grasses that you may not want to drag over."

But if shrimpers find catchable numbers of the crustaceans in habitat-sensitive areas, would they trawl the bottom if it were legal?

"They'd do it," says Jones without hesitation.

Regulating commercial fishermen isn't a popular posture for politicians and neither is regulating development. But solutions do exist and fishery experts believe one of them is limited entry, or allowing only a set number of shrimpers to fish an area. Many believe there are simply too many shrimpers working too little bottom. Another answer could be closing depleted areas altogether.

But without the basic research—and the studies will be costly—fishery managers, and the politicians who must pass the necessary legislation, are sitting ducks for magnum loads of trawler double-talk.

Will they get the funding? The Sea Grant's Stevely had the best answer.

"Everybody is asking for more money. And the fish don't vote." **FS**

Next month: As go the fish, so goes Florida.

## Management Of Tarpon, Bonefish, and Snook In Florida

Gerard E. Bruger and Kenneth D. Haddad

Game fish status is an unaffordable luxury in many countries. Some of the factors that allow society to designate a species as a game fish include availability of a number of edible species, a fairly high overall standard of living, cultural preferences, a willingness on the part of the public to be regulated, and a real or perceived necessity to eliminate commercial harvest.

Tarpon (*Megalops atlanticus*) needed little protection from commercial exploitation because no market existed. Tarpon are consumed in some Central and South American areas but, in Florida, an array of edible species provides many more attractive alternatives. Preference may have precluded development of a market in the past; legislation ensures that one will not develop in the future.

Game fish status for bonefish (*Albula vulpes*) generated little controversy. They were seldom eaten, primarily because of cultural bias and the ready availability of alternatives. In 1981, however, we were asked for the names of producers who could supply to a foreign market "substantial quantities" of headed and gutted bonefish on a year-round basis. Our reply, that bonefish is a game fish and can not legally be sold, totally amazed the requestor. Game fish status, therefore, prevented potentially lucrative exploitation. Such an outcome probably was not anticipated when the law was enacted.

The fishery for snook (*Centropomus undecimalis*) has generated extreme emotion and controversy during much of its history. Restrictions on the snook fishery had their beginnings in the public perception that the net fisheries, both seine and gill-net, were depleting the resource. Legislative restrictions on twine, mesh, and net

sizes effectively ended the snook haul-seine fisheries in Lee and Collier counties (southwest Florida) in 1947 and 1951, respectively, without ever mentioning snook. Biological data, indicating a need for an 18-inch fork length (457 mm FL) minimum size, did not exist when the restriction was imposed in 1953. The 1957 legislation that reserved snook for recreational fishing was originally an attempt to outlaw nets while permitting the sale of fish caught on hook-and-line. All sales were banned, snook was granted game fish status, and limits on recreational catches were also imposed.

Most anglers may have difficulty imagining that game fish status could be a disadvantage to a species. Tarpon, bonefish, and the anglers who fish for them, however, are not typical of Florida's fisheries. The fisheries are small, somewhat seasonal, and, especially in the case of bonefish, restricted geographically. Anglers seeking these fish spend a large amount of money, but they are neither extremely numerous nor highly vocal. As a result, other species have gained higher priorities and very little is known about either tarpon or bonefish.

Snook, on the other hand, are avidly sought by all types of anglers in coastal waters throughout central and southern Florida. Marshall (1958) and Volpe (1959) were conducting pioneering research on snook in Florida during the mid-1950s period of maximum controversy when game fish status was granted. Their work may have been used during the legislative process. Everyone assumed that elimination of commercial exploitation was sufficient to maintain or rebuild stocks, and all snook research was halted when the law passed. Snook suffered from benign neglect on the part of resource man-

agers and fishermen alike, from 1957 to 1974, while Florida experienced a rapid growth in human population and great changes in coastal areas. In 1974, a conservation group from Collier County persuaded the Department of Natural Resources that snook in southwest Florida, the historical center of abundance within the state (Marshall 1958), were worthy of renewed research efforts that they would fund. A major study began in 1976, within five years, we had determined that the fishermen's observations were correct: snook were in trouble. The main results of the study (Bruger in review) included, (1) adult population size in the Naples-Marco Island area was small and dropped from approximately 28,000 individuals in 1977 to approximately 8,600 individuals by 1981; (2) reported tag return rates from recreational anglers ranged from 12.5 to 22% annually, and true exploitation rates were probably considerably higher because not all tags were reported; (3) snook in that area are not particularly migratory — nearly 90% of reported tags came from fish that had moved less than ten miles from the release site, suggesting that Florida's total snook stocks are composed of several sub-populations; and (4) poor survival of larvae and/or juveniles spawned in 1978 produced low recruitment into the adult population in 1981.

Snook laws began to change drastically at this point and, in 1985, nearly 80% of the snook population was illegal to catch. East coast critics of these measures contended that research done on the southwest coast did not apply to "their fishery." The evidence is that snook abundance is much reduced from historical levels throughout Florida despite this dissension. Creel surveys conducted in the St. Lucie estuary, on Florida's east coast, revealed that snook dropped from 26.3% of the total harvest in 1956-1957 to 2.2% in 1978-1979 (Van Os et al 1981). Snook catches in Everglades National Park declined from 19,300 to 4,000 fish between 1972 and 1977 (U.S. National Park Service 1979).

This presentation is not really about tarpon, bonefish, or even snook. It is about jurisdiction and management of Florida's saltwater fisheries; snook just happen to be a convenient case history.

The snook tagging study (Bruger in review) showed that anglers could exert a major impact once the population had been reduced to a low level. The original decline, however, did not result solely from recreational or, for that matter,

commercial fishing pressure. It is now apparent that Marshall's (1958) observations on the effects of environmental alterations on snook populations received less attention than they had deserved. Marshall (1958) felt that outlawing snook seines and imposing minimum size limits had done little to reverse declines of the population and stated, "... they are more likely due to alterations of the habitat produced by habitation and development of Florida, than to fishing." A total prohibition on commercial harvest since 1957 obviously has not halted the decline.

At the 1982 Snook Symposium, in Ft. Lauderdale, Arthur Marshall (1983) presented the following "axiomatic postulate": "In order for a fish population to survive, it must be immersed in water." This concept is deceptively simple, but successful management of recreational or commercial species that inhabit estuarine waters for some portion of their lives depends upon our ability to insure that the species are immersed in water and that the water is suitable for them.

One scenario on the development of Florida, and its related impact on the fisheries, involves a hypothetical Mr. and Mrs. Smith from Anywhere-but-Florida, USA. During a winter vacation to the Sunshine State they realize that fishing and the sunshine were never like this at home in February, so they buy a beautiful new house on a canal. Shortly thereafter, it is summer, and Mr. and Mrs. Smith cannot go outside after 7 p.m. because of the mosquitos. Soon, the elected officials have 6,000 Mr. Smiths complaining and they must act. In some areas the salt marsh and mangrove swamps that serve as mosquito breeding areas are drained by extensive canal systems. In other areas, dikes isolate the marsh from tidal waters. The Smiths, meanwhile, are applying truckloads of fertilizer and chemicals to their lawn and watering 24 hours a day in a valiant effort to keep it green and stop the hordes of insects. Then, one day, Mr. Smith realizes that fishing is not as good as in the past and demands that something be done to restore his fishing. He makes his demands from the house that sits on land that once was bay bottom and supported mangroves and seagrasses.

Nearly three-fourths of Florida's human population live in coastal areas. These people required alterations of wetlands habitat for residential and commercial development, flood control, agriculture, mosquito control, and other reasons. These requirements often conflict with

the concept of keeping the animals immersed in water and, as a result, much critical wetlands habitat has been permanently altered. Once-productive fisheries habitats now support dense growths of condominiums.

A general awareness of the intimate relationship between habitat and fisheries production now exists. Unfortunately, quantification of habitat-fishery relationships has received little attention historically, and the scientific community has been unable to provide data for effective management of a species. Habitat losses are now being documented and the figures for Florida are alarming. Approximately 30% of all vegetated coastal wetlands habitat losses in the United States occurred in Florida (Frayer et al 1982). Tampa Bay has lost 44% of its mangrove and marsh habitat and 81% of its seagrasses since development began in the area (Lewis et al 1979, 1985). The Indian River lagoon serves as a nursery area for tarpon (Harrington and Harrington 1982), bonefish (R.G. Gilmore, Harbor Branch Foundation, personal communication; Bruger, unpublished data), and snook (Gilmore et al 1983). An estimated 30% of the seagrasses and 86% of the mangrove and marsh have been lost in this area (Haddad et al in preparation). The mangrove and marsh losses resulted primarily because of mosquito impoundments that effectively remove habitat from fisheries production.

Habitat alterations are not limited to the physical destruction of a habitat type. They also involve alterations to traditional water-flow patterns. Charlotte Harbor, on Florida's west coast, has undergone development, but most of it has occurred since the late 1960s. The area was targeted as one of Critical State Concern, and growth management plans provide a buffer between the estuary and upland development. Shoreline margins of the estuary have been preserved and mangrove acreage has actually increased by 10% since the 1940s (Harris et al 1983). Seagrass acreage has decreased 29%, however, probably because of changes in ambient water quality by urban, suburban, industrial, and agricultural runoff and discharge, dredging activities, and fresh water flow changes (Harris et al 1983).

The 1956-1957 creel study in the St. Lucie estuary was part of an evaluation of the effects of proposed U.S. Army Corps of Engineers alterations to the St. Lucie County Canals Project. These alterations would have doubled flow rates

in existing canals in some cases (U.S. Department of the Interior 1959). The report concluded that, "The project, as planned, would be detrimental to the fisheries of the North Fork and St. Lucie Estuaries." (U.S. Department of the Interior 1959). The Corps proceeded with the project despite the warning. The 1978-1979 creel survey evaluated effects of the discharges on angling catch rates, and the authors stated that, "It is our opinion that the estuary is changing and, as a result, the desirable sport fishes are becoming less abundant. Other estuarine species are now surpassing them in CPE." (Van Os et al 1981).

Naples Bay, on the southwest coast, now receives 20 to 40 times more fresh water input than it did before the opening of the Golden Gate Canal in 1964 (Simpson 1979). This has resulted in strong salinity stratification, substandard dissolved oxygen concentrations during most of the year (Hicks 1979), and reduced species abundance and diversity in the upper Bay and Gordon River (Yokel 1979).

The situation is reversed in the Everglades. Approximately 1,500 miles of canals, including those connecting with the St. Lucie estuary have been dug since the late 1800s for water control, drainage, and "conservation" (Rote 1981). Reduced water levels, reduced water retention time, and hypersaline conditions in Florida Bay, resulting from these canals, have caused a "catastrophic reduction in nursery habitat for estuarine finfish and shellfish." (Browder and Moore 1981; Spear 1981; Marshall 1983).

### Summary

Rational fisheries management cannot occur unless the habitat of the resource is managed as well. Fisheries managers may have jurisdiction over management of a species, but they have little, if any, jurisdiction over the physical environment of that species. The Indian River lagoon is a good example of a multi-jurisdictional system. The lagoon is bordered or managed by six counties, many municipalities, and at least 49 federal, state, county, or local agencies (Panico and Barile 1986). Fisheries managers generally have not had too much impact on the planning process in the system.

More than 70% of Florida's recreational and commercial finfish species utilize estuarine areas for some or all of their lives (Harris et al 1983). A fundamental law of physics states that for every action, there is an equal, but opposite,

reaction. Actions involving the wetlands or water resources will affect the state's fisheries either positively or negatively. The choice is ours.

Conflicts between recreational and commercial fishermen over estuarine-dependent species generally concern allocation of resources reduced by habitat destruction. Cooperation by both sides to protect the habitat of these resources might forestall further conflicts. A resource and its environment cannot be treated as distinct entities. To maintain or rebuild our fisheries, habitat concerns must be considered during the planning process.

Forty years of snook management have produced numerous regulations on fishermen, but no increase in the snook population. Without proper management of habitat, fisheries management merely becomes an exercise in managing people.

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## THE ROLE OF GEOGRAPHIC INFORMATION SYSTEMS IN MANAGING FLORIDA'S COASTAL WETLAND RESOURCES

Kenneth D. Haddad\* & Barbara A. Hoffman\*

Florida is one of the fastest growing states in the nation and this trend is expected to continue into the twenty-first century. The impact of this growth on our wetland ecosystems is difficult to assess and monitor. To deal with the complex and often conflicting issues of growth versus environment, coastal resource managers require rapid access to a comprehensive coastal resource database from which they can extract and synthesize pertinent data to aid in their decision-making. Although the concept of using resource data to manage the resources is not new, the reality of such databases is that they have been limited because of the technical and organizational complexities associated with implementation. With rapid advances in computer and software technology, the creation of comprehensive resource databases is now possible at the state and local level. The data requirements of the resource manager are often geographical in character and much of the resource software technology is addressing this requirement.

### Geographic Information Systems

"Geographic information system" (GIS) is a generic term and may be defined as a computer system or network that has as its primary function the analysis and handling of geographic (spatial) data. A GIS, by hardware and software design, is able to accept large volumes of spatial data from a variety of sources and to manipulate, retrieve, analyze, and display the data efficiently according to user-defined specifications (Marble and Peuquet, 1983). Any database that is geographically referenced has the potential for GIS entry and, certainly, many aspects of Florida's coastal wetland resources meet this criterion. Some GIS software designs incorporate capabilities to access attribute (tabular non-spatial) data associated with a geographic location. An example of this would be the ability to access, on a computer terminal, a permit application or tax record based on the location of a parcel of property displayed graphically in a map form. GIS applications are numerous but a clear understanding of the

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various types of GIS data and database development are required for successful implementation.

Two basic data structures are utilized in GIS systems: raster and vector. GIS software packages, with many variations of these data structures, are becoming increasingly available within both the non-proprietary (tax-dollar developed) and commercial markets.

A raster-based GIS is one in which the geographic data are presented as discriminate cells of a predetermined geographic size (i.e., 1/4 acre, 1/3 acre, etc.) with each cell having one data value commensurate with the type or layer of data being displayed (Figure 1). The user actually sees the specific numerical values as colors or gray shades on a computer screen. This type of GIS database is an extension of digital image processing of aircraft and satellite scanners and, more recently, digital photographs and video imaging.

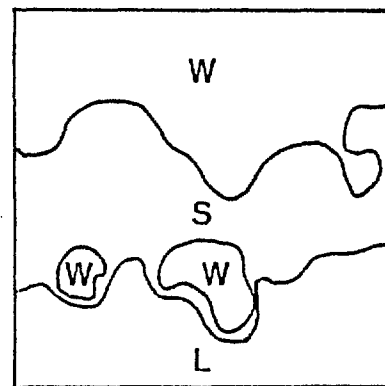
A vector-based GIS utilizes a map display in which a series of x,y points are connected by lines and arcs and are presented on a map or computer screen as polygon outlines (Figure 2). Vector-based GIS's generally are extensively modified Computer-Aided Design (CAD) packages and are logical extensions of non-computerized map drawings.

1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1
1	2	2	1	1	1	1	2
2	2	2	2	1	2	2	1
2	2	2	2	2	2	2	2
2	1	3	1	1	2	3	3
3	3	3	3	1	3	3	3
3	3	3	3	3	3	3	3

LAND COVER, RASTOR

1 = water  
2 = seagrass  
3 = land

Figure 1



LAND COVER, VECTOR

W = water  
S = seagrass  
L = land

Figure 2

These two basic types of data are often interchangeable, but they also are substantially different in many aspects of data manipulation, geographic accuracy,

overlay capabilities, attribute handling, and data entry. In addition, some GIS's give the user all possible options and benefits of both the raster and vector types of data. These aspects will not be presented in detail, but one must fully explore the ranges of GIS capabilities prior to a database development initiative.

### Marine Resource Geographic Information System

A program has been initiated at the Florida Department of Natural Resources (FDNR), with funding through the Florida Department of Environmental Regulation and the NOAA Office of Ocean and Coastal Resource Management, to develop a coastal wetland resources spatial database and incorporate these data into a computer-based information system. The initial phase of the FDNR program was to institute a Marine Resources Geographic Information System (MRGIS) and develop techniques in remote sensing and image analysis for mapping and monitoring marine wetlands in Florida's coastal zone. Haddad and Harris (1985a) concluded that the time constraints and enormous funding required for conventional photogrammetric mapping preclude standard approaches to mapping and monitoring a coastline of over 2,172 km. Thematic Mapper (TM) data from Landsat satellite (1/4 acres spatial resolution) was evaluated and chosen as the primary database in the mapping procedure. The TM data are not effective in all mapping requirements and are supplemented with aerial photography where necessary (Haddad and Harris, 1985b). The success of the MRGIS now depends on (1) transformation of the raw LANDSAT TM data into a wetlands/land-use map and (2) the use of geographically referenced TM data as the coordinate reference system for overlays of ancillary geographic data. We emphasize that the wetlands mapping effort provides just one of many layers of data required for the MRGIS.

Since TM data are in a raster format, the MRGIS required a raster-based GIS. ELAS, a non-proprietary software package developed by NASA Earth Resources Laboratory, was chosen as the primary tool for MRGIS development. ELAS is a modular FORTRAN overlay package that is machine independent (Junkin et al. 1981). ELAS, as described by Marble and Peuquet (1983), may be categorized as a raster-based GIS. The exceptional flexibility of the ELAS software package makes it a powerful image processing/GIS tool. The ability to manipulate and sort layered data is not based on a "user friendly approach"; thus, ELAS is not recommended for direct infusion into a management situation. Our choice for this software was based on the variety of remotely sensed data interfaces and image processing capabilities, crucial elements for successful implementation of the MRGIS. The data created on the MRGIS can be manipulated by the GIS capabilities of ELAS or is easily compatible with

any raster-based GIS on the market (see Data Dissemination).

### MRGIS Data Overlays

A major function of a GIS is to utilize compatible, multiple, co-referenced layers of geographic data (Figure 3) to create a new file containing the results (pictorially and numerically) of a user generated query. The ability to enter ancillary data (such as bathymetry, sediment and soil types, etc.) is the feature that gives the GIS such value as a tool in resource management. This approach has been applied to many different situations, such as forestry and fire control management (Root et al., 1986) and land use management (Nystrom et al., 1986). A comprehensive applications review of GIS technology is in Geographic Information Systems Workshop (1986). The MRGIS overlay database is being designed specifically to provide the Florida resource manager with the capability to assess and monitor submerged and emerged wetland environment. This is important for balanced and informed management of these sensitive lands for dependent fisheries, non-game wildlife, and burgeoning population growth in the coastal zone.

MRGIS data layers input for the Tampa Bay region of Florida include vegetation cover, waterbird nesting sites, sediment distribution, topography, open/closed shellfish areas, manatee sanctuaries, pertinent jurisdictional boundaries, water currents, and seasonal averages of salinity, temperature, and chlorophyll. Additional data layers can be added when necessary.

A typical query of this system could be based on the following hypothetical scenario. An Aquatic Preserve manager in the Tampa Bay region has determined that the wading bird populations are declining because the parent birds are unable to feed their young adequately during nesting season. These birds only range three kilometers from the nesting site during the active nesting season and feed only in shallow, vegetated wetland areas with sandy sediment. In order to grant special protective status on these feeding habitats, the manager needs to know all the areas within the Aquatic Preserve that meet these conditions (see Figure 3).

The results of such a GIS query are immediately available to the Aquatic Preserve manager (Figure 4). This is just one example of the many queries that could be imposed on the data. The queries are generally based on simple mathematical logic and can utilize various types of modelling (i.e., soil runoff coefficients, biological carrying capacities, etc.) to generate a final data set.

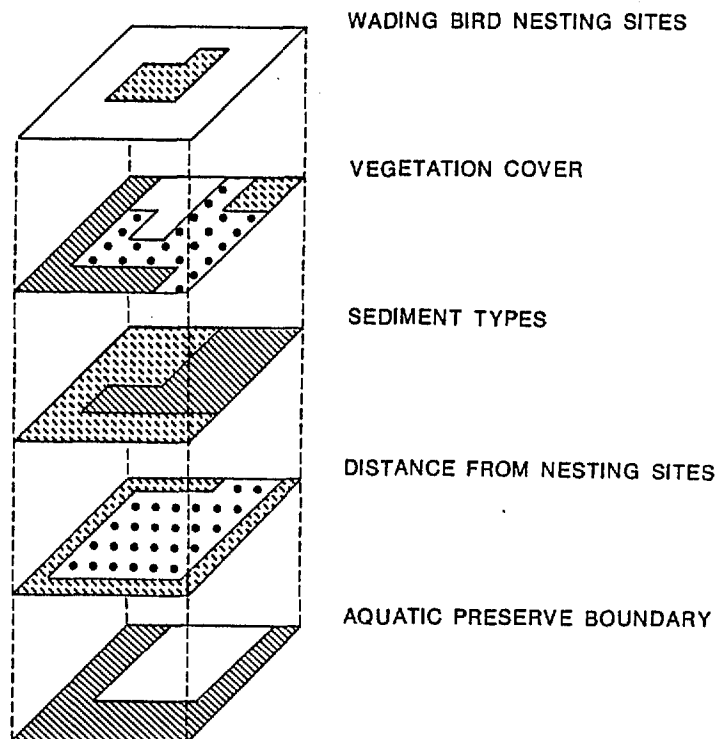


Figure 3

### Data Dissemination

As the MRGIS database has been developed, demands to access that information have increased. Most resource managers deal with either hand-drafted maps or computer produced vector-type maps from line plotters. Since raster data cannot easily be conveyed in these forms, two primary approaches to data dissemination have been taken with the MRGIS.

1. Raster data are pictorial in character and are displayed in color on a computer screen. Each color has a specific meaning and the user can readily identify and visually extract the information subsets of an image. In the past, simple photographic techniques have been used in the past to present a hardcopy of the data, but this has proven expensive and impractical in many applications. An inkjet printer, which has the capability of reproducing 4,096 different colors in an image (photographic like output) format, has been interfaced to the MRGIS. Utilizing a combination of in-house and commercially available software, the ELAS data files can be reproduced on paper, at minimal cost, in any scale and in a variety of earth coordinate systems. Figure 4 is a black and white production from the inkjet

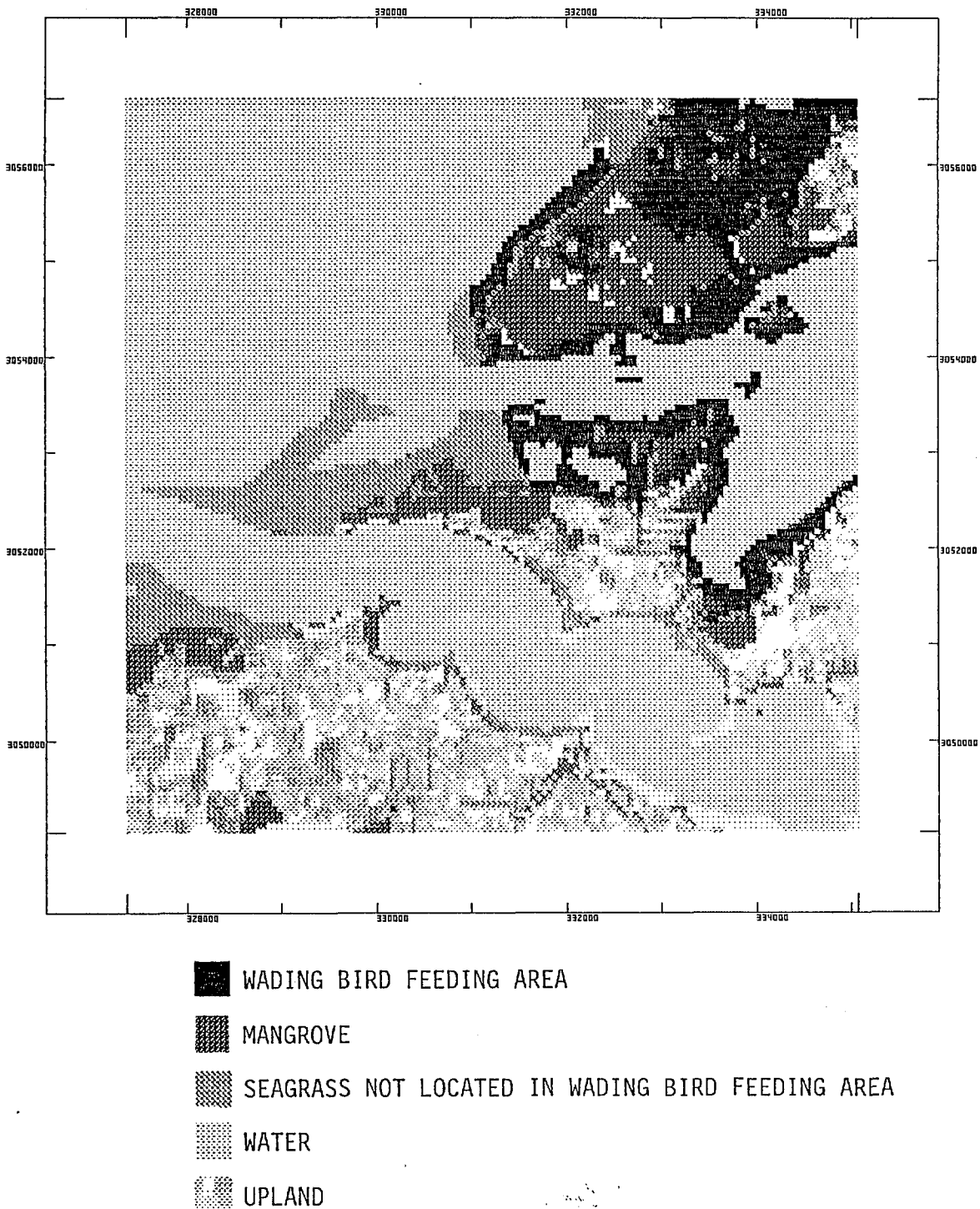


Figure 4. Inkjet printer output in a Universal Transverse Mercator map projection (tick marks = 1000 m). This print represents the results of a management query on a multilayered data set (see Figure 3). A standard inkjet print would be in color (256 shades) and more defined pictorially. The scale of the print is 1:67000. The scale of the data on the MRGIS is 1:24000; thus, this print does not present full resolution.

printer and represents the final data set created from a query based on Figure 3. Products from the inkjet printer for data dissemination have proven useful for many resource queries.

2. Hardcopy products are applicable in many situations, but the real value of working with digital data in a GIS is the ability to manipulate and query the data in a real-time management decision-making process. The only method for rapid access is direct computer access. Real-time access to a mainframe computer housing the data is technically and economically impractical because many resource managers are in field situations and graphic data volumes are so large. An alternative approach is to make the data available on microcomputers with their own GIS capabilities.

A pilot program to evaluate the potential of downloading MRGIS data to a microcomputer for use in a management setting has been completed. Figure 5 schematically depicts the maximum microcomputer GIS configuration. The peripherals in the configuration can be added or deleted, depending on user needs and budgets. One major obstacle in

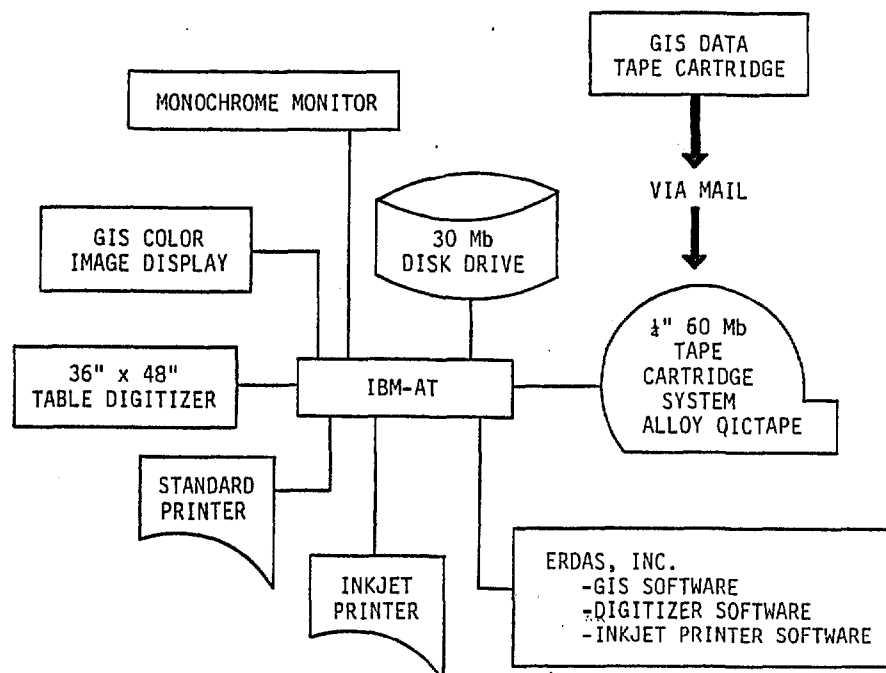


Figure 5

working with geographic data is the large data volume. A typical file exceeds 5 megabytes in storage space, precluding data transfer by floppy disk. Direct data

transfer to microcomputer by modem is currently not feasible due to expense and transfer times. Transfer through the mail on a medium was considered the most viable method. Nine track tapes are a standard data transfer method for mainframe computers and can be used in the microcomputer environment, but they are expensive and not used universally. Optical disks will eventually be the preferred method, but that technology has not advanced sufficiently. We are currently transferring data on 1/4 inch tape cartridges. The tape cartridge industry is not standardized, so transfer can only be accomplished on compatible tape drives. The system we chose was an file-oriented tape back-up unit. It can store up to 60 megabytes of data in separate files on standard tape cartridges. Data are transferred from the mainframe MRGIS via an RS232 serial interface to an IBM-AT. The data are reformatted during the transfer to conform to the GIS software used on the microcomputer. The data files are then transferred to the tape cartridges as DOS files and sent via mail to the field GIS.

As part of the pilot project, two commercially available, raster-based micro-GIS's were installed, one at the East Central Florida Regional Planning Council and the other at an FDNR Aquatic Preserve in Naples, Florida. The ERDAS, Inc. GIS has a basic configuration that allows a color display of the data, various GIS manipulations, and data deletions and additions. Capabilities important to the basic system and available as separate additions are table digitizing and color inkjet printer hardcopy generation (see Figure 4). A commercial system was chosen because the careful software planning and design provide simple menu-driven access to the data. This puts the GIS within the realm of potential use by the resource manager.

The development of the MRGIS and the ability to transfer GIS data to microcomputers has been a technical success. Management utilization has not been fully assessed, but the initial results are encouraging. The East Central Florida Regional Planning Council (ECFRPC) used the micro-GIS to target wetlands requiring different levels of planning. Wetland cover for Brevard County, Florida, was developed on the MRGIS using LANDSAT TM data and downloaded to the ECFRPC. ECFRPC then used U.S. census tract populations and regionally developed population projections to create a data overlay of predicted changes in population densities throughout the county from the year 1985 to 2000. These projections were then weighted by density and analyzed with the wetland data in order to target wetlands of high to low potential for impact by population growth. This information can now be used in prioritizing wetland management in the growth management planning process. The FDNR micro-GIS in Naples, Florida, is being used to develop a comprehensive database on the Rookery Bay, Cape Romano, and Ten Thousand Islands Aquatic

Preserves. This database will be an extension of the type of overlays being developed for Tampa Bay. Again, the wetlands resources were developed on the MRGIS using TM data and downloaded to the Aquatic Preserve GIS. Additional resource data are being entered using a table digitizer capability. The micro-GIS will be the primary management tool for these Aquatic Preserves.

#### Conclusion: The Role of the MRGIS in Resource Management

MRGIS raster database development and data dissemination by hardcopy and, more importantly, to microcomputer, have proven to be the technological success of the GIS concept. This strategy for data dissemination will also provide rapid access of large volumes of geographic data to the resource manager. The MRGIS, combined with microcomputer field systems, offers a desktop, user-friendly approach, with a color map-oriented display. This system allows resource managers to effectively utilize the best available data in resource planning and decision-making. We also plan to link geographically-oriented data with tabular data (such as fisheries statistics, boat licenses, and environmental permits) to provide state, regional, and local resource managers and planners with additional information regarding the use of natural resources.

Even though the MRGIS has been successfully tested in small scale management situations, the GIS concept may not be accepted or incorporated into management structure, primarily because upper level management lacks familiarity with GIS technology. Consequently, GIS development is not initiated at this level, but at the technical level, which often results in a minimal and inadequate commitment to develop a GIS.

The success of the MRGIS is attributed to definitive goals, established in its development, that were to (1) develop a spatial inventory of marine fisheries habitat using remote sensing techniques, (2) determine and monitor trends in habitat change, (3) integrate ancillary data from a variety of sources as GIS overlays for fisheries management queries, and (4) demonstrate the potential of an image processing raster-based GIS for research, management, and education. These goals currently govern the role of the MRGIS in management of Florida's coastal resources, but an interest in applying GIS techniques to many aspects of resource management is growing.

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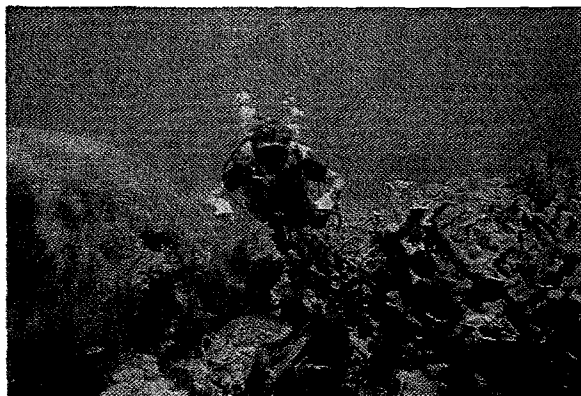
## YOUR HELP IS NEEDED

The tropical setting in Florida's reefs attracts millions of visitors annually. In order to minimize human damage to the corals, everyone's cooperation is needed. The reefs are well marked on navigation charts; if you are not familiar with the area, refer to the charts.

Every year careless boaters run aground, destroying coral colonies that are hundreds of years old. Seen from the surface, reefs have a unique golden-brown color. If you see brown, you may be about to run aground. Be cautious when anchoring your boat. Do not deploy the anchor directly in coral. Usually there are sandy areas close by; anchor in the sand. Many popular reefs off Key Largo and at Looe Key National Marine Sanctuary have special anchor buoys for mooring. In these areas, tie up to the buoys, rather than anchoring. Do not dispose of trash, bilge washings and other debris on or near the reefs!

Fishermen should avoid shallow coral reefs when trolling. Hooks can scar and injure the coral, leaving it vulnerable to infection by microscopic organisms that can kill the animals. Lobster fishermen should avoid placing traps on reefs. Heavy traps break corals and damage the bottom when the traps are pulled.

When diving or snorkeling, look—but do not touch! Do not grasp, stand or sit on living coral. You may damage the coral and hurt yourself in the process. All coral is protected. It is against the law to collect, harvest or sell coral in Florida and adjacent federal waters.



Florida coral reefs, with whom we share the seas, are significant, unique natural resources. Be a responsible visitor—insure the continued vitality of Florida's coral reefs.

Florida Department of Natural Resources  
Bureau of Marine Research  
100 Eighth Avenue S.E.  
St. Petersburg, FL 33701-5095

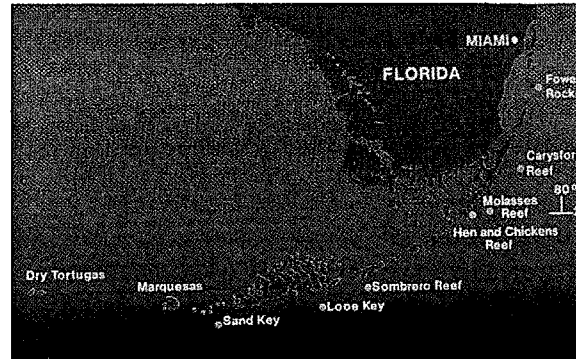
This publication was produced at a cost of \$2,745, or \$.068 a copy, to distribute information on Florida's coral reefs. Funds provided by DER office of Coastal Management, through a grant from the U.S. Office of Ocean and Coastal Resource Management, NOAA, under the Coastal Zone Management Act of 1972, as amended.



Florida is the only state in the continental United States to have extensive shallow coral reef formations near its coasts. These reefs extend from near Stuart on the Atlantic coast to the Dry Tortugas, west of Key West, in the Gulf of Mexico. The most prolific reef development occurs seaward of the Florida Keys. The reefs here are spectacular and rival those of many Caribbean areas. Approximately 6,000 coral reefs are found between Key Biscayne and Dry Tortugas.

### FLORIDA REEF FACTS

Florida's coral reefs came into existence 5,000 to 7,000 years ago when sea levels rose following the Wisconsin Ice Age. Reef growth is slow; estimates range from one to sixteen feet every 1,000 years.

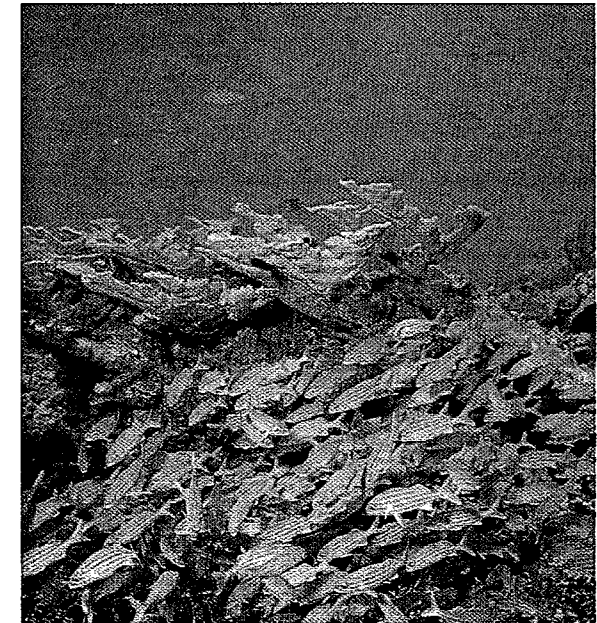


Stony corals are the major reef architects. Polyps, the living portion of the coral, extract calcium from seawater and combine it with carbon dioxide to construct the elaborate limestone skeletons that form the reef backbone. Coral polyps are united into colonies. An individual colony grows one-half to seven inches a year, depending on the species. Corals start life as free-living larvae that later settle on the sea floor and develop into massive, sedentary limestone formations.

Though reef corals are classified as animals, there is, in fact, a complex of microscopic plants that lives within the animal tissues (a symbiotic relationship). The animals benefit from the energy that the plants provide through photosynthesis. The plants are protected within the coral tissues and gain nutrients from animal wastes. These tiny plants are called zooxanthellae and are responsible for much of the color seen in reef corals.

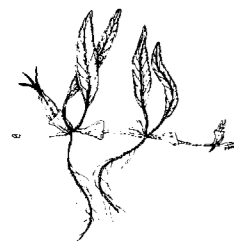
Coral reefs are specialized habitats that provide shelter, food and breeding sites for numerous plants and animals. They form a breakwater for the adjacent coast, providing natural storm protection. They are very important to southeast Florida's economy. Recreational and commercial fishing annually bring many millions of dollars to the state. The attractions of the coral reef communities contribute greatly to the total value of Florida's fisheries.

Coral reef development occurs only in areas with specific environmental characteristics: a solid structure for the base; warm and predictable water temperatures; oceanic salinities; clear, transparent waters low in phosphate and nitrogen nutrients; and moderate wave action to disperse wastes and bring oxygen and plankton to the reef.

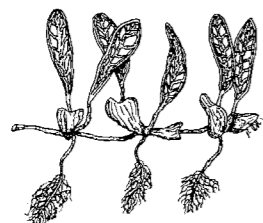




Star-grass (*Halophila englemanni*)



Johnson's Sea-grass  
(*Halophila johnsonii*)



Paddle-grass  
(*Halophila decipiens*)

seagrasses was documented through comparison of aerial photographs from 1944 to 1982.

Florida Department of Natural Resources, Bureau of Marine Research scientists are studying changes in Florida's coastal fisheries habitats. By analyzing aerial photographs from the 1940's and 1950's and satellite imagery and aerial photographs from the 1980's, the scientists are able to evaluate habitat change.

Several sites on the east Florida coast have been analyzed, among them are Ponce Inlet, just south of Daytona Beach, and the Indian

River from Sebastian Inlet south to St. Lucie Inlet. At the Ponce Inlet site a 100 percent loss of seagrasses was noted. This destruction was due primarily to dredge and fill activities for development and the Intracoastal Waterway. A 7 mile stretch of estuary surrounding the Sebastian Inlet has experienced a 38 percent decline in seagrass habitat since 1951. Another study site just north of Fort Pierce Inlet was assessed for change in habitat over time. A 25 percent loss of seagrasses was documented in this area since 1958.

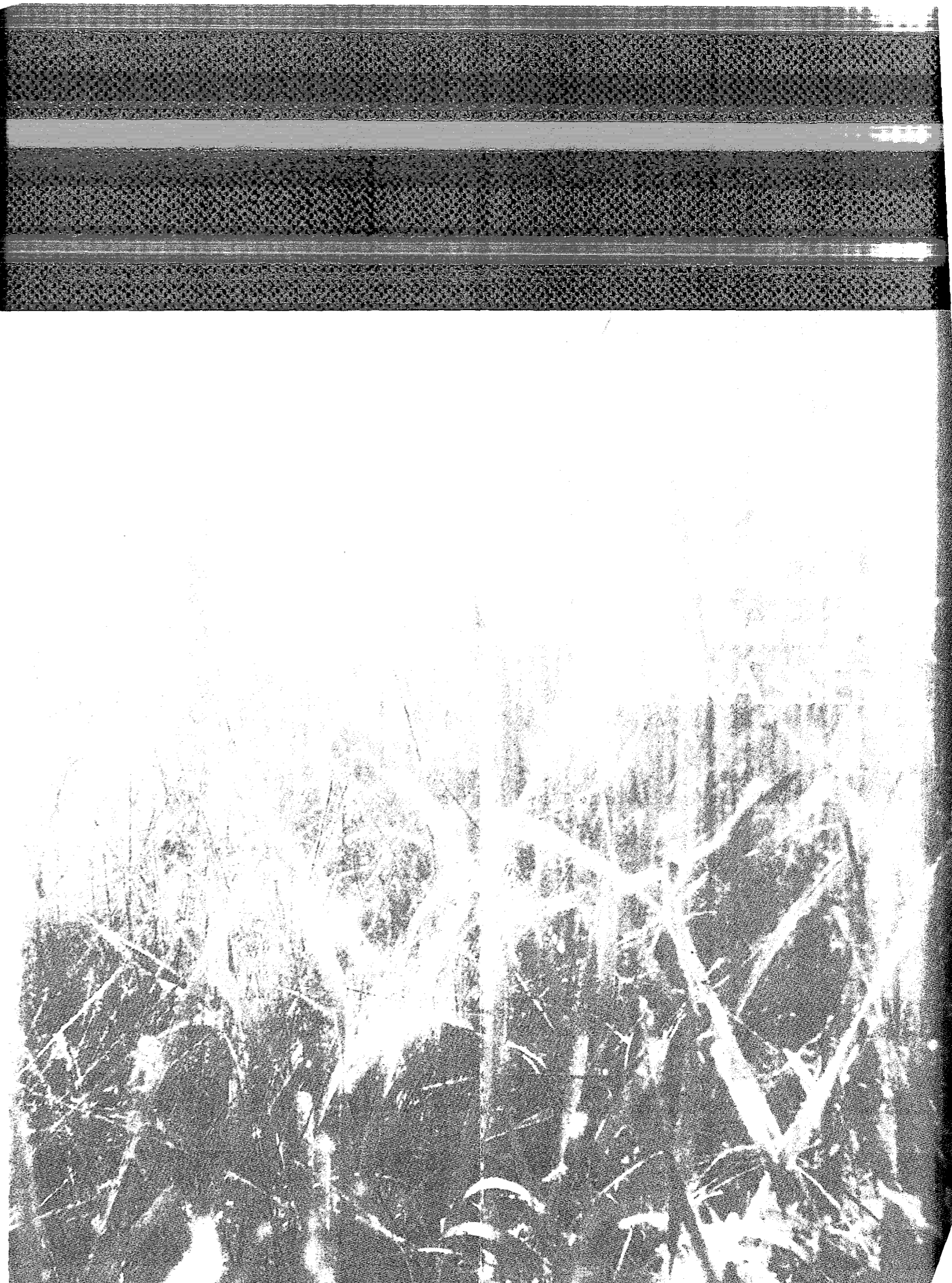
The studies documenting fisheries habitat alterations in Florida, such as the seagrass losses described earlier, are proving helpful to local and state officials. They are increasing public awareness about the problem of fisheries habitat losses and are providing incentive to address this serious problem in Florida's coastal zone.

For more detailed information about Florida's Seagrasses, write to:

**Florida Department of Natural Resources**  
**Bureau of Marine Research**  
**P.O. Box F**  
**St. Petersburg, FL 33731**



This public document was promulgated with state and federal funds at a cost of \$9480.31, or \$.05 per copy, to provide information about the coastal zone.



# What Are Seagrasses?

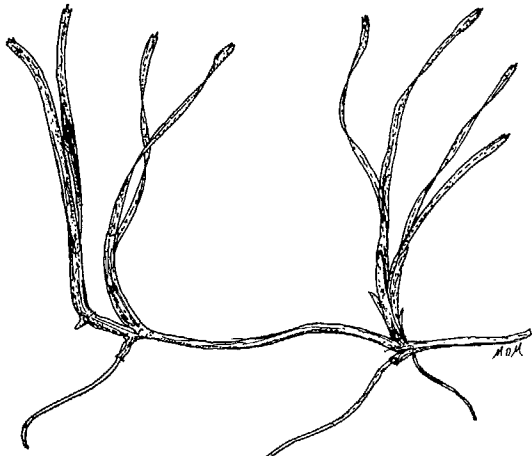
Seagrasses are flowering plants that live underwater. Like land plants, seagrasses produce oxygen. The depth at which seagrasses are found is limited by water clarity because they require light. Although seagrasses occur throughout the coastal areas of the state, they are most abundant from Tarpon Springs northward to Apalachee Bay. Seagrasses occur in protected bays and lagoons and also in places along the continental shelf in the Gulf of Mexico.

Florida's estimated 502,000 acres of seagrasses are important natural resources that perform many significant functions: 1) they help maintain water clarity by trapping fine sediments and particles with their leaves, 2) they can stabilize the bottom with their roots and rhizomes in much the same way that land grasses retard soil erosion, 3) they provide habitat for many fishes, crustaceans, and shellfish, 4) seagrasses and the organisms that grow on them are food for many marine animals, and most importantly, 5) they are nursery areas for much of Florida's recreationally and commercially important marine life.

Seagrass leaves provide excellent protection for young marine animals from larger open-water predators. Some animals, such as manatees, eat seagrass blades. Other animals derive nutrition from eating algae and small animals that colonize seagrass leaves. These colonizing organisms provide an additional link in the marine food chain.



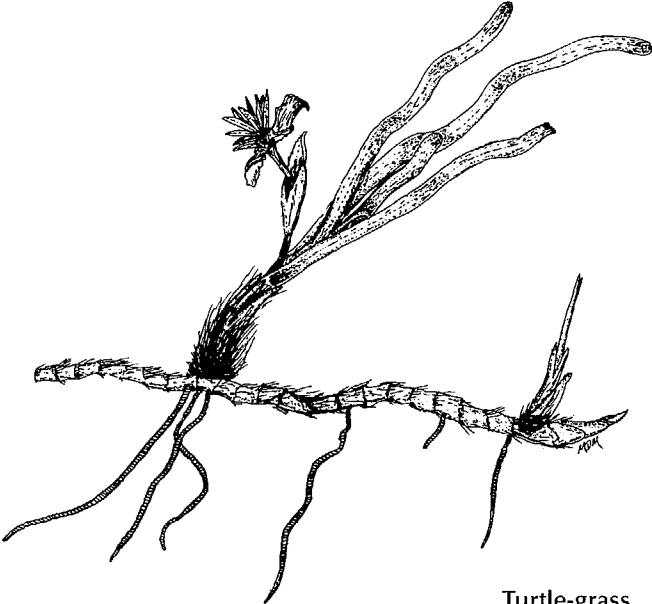
Widgeon-grass  
(*Ruppia maritima*)



Shoal-grass (*Halodule wrightii*)

## Florida's Seagrasses

Although approximately 52 species of marine seagrasses exist worldwide, only seven species are found in Florida waters. Four of these are wide spread in Florida and extend beyond its borders. *Ruppia maritima*, commonly called



Turtle-grass  
(*Thalassia testudinum*)

widgeon-grass, grows in both fresh and salt-water and is widely distributed throughout Florida's estuaries.

Shoal-grass, *Halodule wrightii*, is an early colonizer of disturbed areas and usually grows in water too shallow for other species.

Turtle-grass, *Thalassia testudinum*, the most common of the Florida seagrasses, characteristically has deeper root structures than any of the other seagrasses.

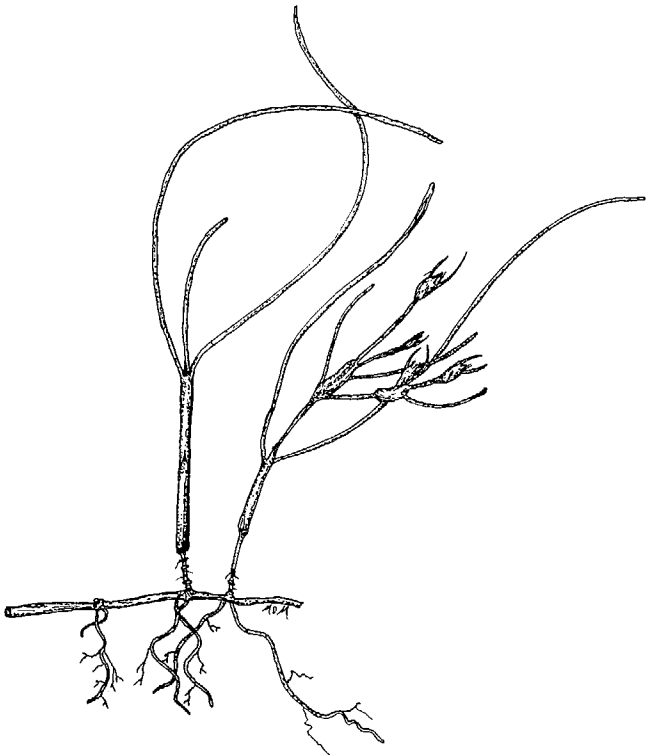
Manatee-grass, *Syringodium filiforme*, is easily recognizable because its leaves are cylindrical.

The other three are species of *Halophila*: star-grass, *Halophila engelmannii*; paddle grass, *Halophila decipiens*; and Johnson's seagrass, *Halophila johnsonii*. These small, fragile seagrasses are sparsely distributed in Florida and only limited information about them exists.

# Seagrass Losses in Florida

Seagrasses are a valuable part of Florida's marine environment but they are disappearing at an alarming rate. Dredge and fill projects and degraded water quality, as well as other activities, are responsible for their precipitous decline.

Along the southwest Florida coast there are two major bay systems with similar physical features but dramatically different histories. Tampa Bay has experienced the stresses of a developed, urbanized bay system. Charlotte Harbor, on the other hand, is one of the most natural estuaries remaining in Florida. During the past 100 years, Tampa Bay has experienced an 81 percent decline in seagrass acreage. A 29 percent decrease in area of Charlotte Harbor



Manatee-grass (*Syringodium filiforme*)

to evaluate habitat changes by analyzing aerial photographs from the 1940's and 1950's, and satellite imagery and aerial photography from the 1980's. Frequently the changes illustrate loss of mangrove acreage. Through researching the history of study sites, these losses are often attributed to human activities.

Tampa Bay, located on the southwest Florida coast, has experienced considerable change. It is one of the ten largest ports in the nation. Over the past 100 years, Tampa Bay has lost over 44 percent of its coastal wetlands acreage; this includes both mangroves and salt marshes.

The next major bay system south of Tampa Bay is Charlotte Harbor. Unlike Tampa Bay, Charlotte Harbor is one of the least urbanized estuarine areas in Florida. However, there has been some mangrove destruction here also. Punta Gorda waterfront development accounts for 59 percent of the total loss. An increase in mangrove acreage was noted in parts of the Harbor. This is due to changes in the system. As tidal flats were colonized by mangroves, tidal flat acreage decreased and mangrove acreage increased. Spoil islands, created as by-products of dredging, also provide suitable habitat for mangroves.

A changing system was also observed on the southeast Florida coast in Lake Worth, near West Palm Beach. Lake Worth naturally evolved from a saltwater lagoon to a freshwater lake. Human changes modified the lake back to an estuarine lagoon. Lake Worth has experienced an 87 percent decrease of its mangrove acreage over the past forty years. Mangroves appear to be replaced by Australian pines and urbanization. The remaining 276 acres of mangroves occur in very small scattered areas and are now protected by strict regulations.

Another study site included the Indian River from St. Lucie Inlet north to Satellite Beach.

Indian River is the longest saltwater lagoon in Florida. There are just under 8,000 acres of mangroves within the study site, but only 1,900 acres are available as fisheries habitat because of mosquito impoundments. Consequently, 76 percent of the existing mangrove areas are not productive to fisheries. A total of 86 percent of the mangrove areas have been lost to fisheries since the 1940's.

State and local regulations have been enacted to protect Florida's mangrove forests. Mangroves cannot be removed, pruned or disturbed on either state or private land without a permit from the Florida Department of Environmental Regulation. Local laws vary, so be sure to check with officials in your area before taking any action.

Mangroves are one of Florida's true natives and are part of our state heritage. It is up to us to ensure a place in Florida's future for one of our most valuable coastal resources...mangroves.

For more detailed information about Florida's Mangroves, write to:

**Florida Department of Natural Resources**  
**Bureau of Marine Research**  
**P.O. Box F**  
**St. Petersburg, FL 33731**



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Cover Photo by Wendy Wilson

6/85



## What Are Mangroves?

Mangroves are one of Florida's true natives. They thrive in salty environments because they are able to obtain freshwater from saltwater. Some secrete excess salt through their leaves, others block absorption of salt at their roots.

Florida's estimated 469,000 acres of mangrove forests contribute to the overall health of the state's southern coastal zone. This ecosystem traps and cycles various organic materials, chemical elements, and important nutrients. Mangrove roots act not only as physical traps but provide attachment surfaces for various marine organisms. Many of these attached organisms filter water through their bodies and, in turn, trap and cycle nutrients.

The relationship between mangroves and their associated marine life cannot be overemphasized. Mangroves provide protected nursery areas for fishes, crustaceans, and shellfish. They also provide food for a multitude of marine species such as snook, snapper, tarpon, jack, sheepshead, red drum, oyster, and shrimp. Florida's important recreational and commercial fisheries will drastically decline without healthy mangrove forests.

Many animals find shelter either in the roots or branches of mangroves. Mangrove branches are rookeries, or nesting areas, for beautiful coastal birds such as brown pelicans and roseate spoonbills.

## Florida's Mangroves

Worldwide, more than 50 species of mangroves exist. Of the three species found in Florida, the red mangrove, *Rhizophora mangle*, is probably the most well-known. It typically grows along the water's edge. The red mangrove is easily identified by its tangled, reddish roots called "prop-roots." These roots have earned man-



Red Mangrove (*Rhizophora mangle*)

groves the title, "walking trees." The red mangrove in particular appears to be standing or walking on the surface of the water.

The black mangrove, *Avicennia germinans*, usually occupies slightly higher elevations upland from the red mangrove. The black mangrove can be identified by numerous finger-like projections, called pneumatophores, that protrude from the soil around the tree's trunk.

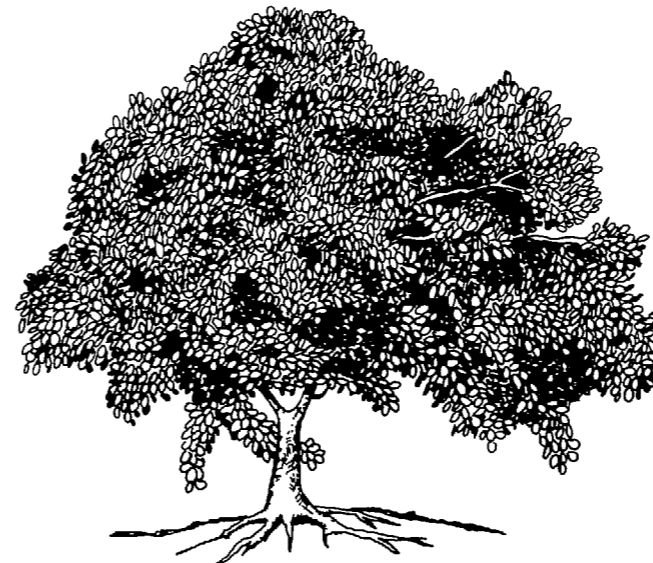
The white mangrove, *Laguncularia racemosa*, usually occupies the highest elevations farther upland than either the red or black mangroves. Unlike its red or black counterparts, the white mangrove has no visible aerial root systems. The easiest way to identify the white mangrove is by its leaves. They are elliptical, light yellow-

green, and have two distinguishing glands at the base of the leaf blade where the stem starts.

All three of these species utilize a remarkable method of propagation. Seeds sprout while still on the trees and drop into the soft bottom around the base of the trees or are transported by currents and tides to other suitable locations.

Florida's mangroves are tropical species, therefore they are sensitive to extreme temperature fluctuations as well as subfreezing temperatures. Research indicates that salinity, water temperature, tidal fluctuations, and soil also affect their growth and distribution. Mangroves are common as far north as Cedar Key on the Gulf coast and Cape Canaveral on the Atlantic coast. Black mangroves can occur farther north in Florida than the other two species. Frequently, all three species grow intermixed.

People living along the south Florida coasts benefit many ways from mangroves. Mangrove forests protect uplands from storm winds, White Mangrove (*Laguncularia racemosa*)



Artwork courtesy of U.S. Fish & Wildlife Service



Black Mangrove (*Avicennia germinans*)

waves, and floods. The amount of protection afforded by mangroves depends upon the width of the forest. A very narrow fringe of mangroves offers limited protection while a wide fringe can considerably reduce wave and flood damage to landward areas by enabling overflowing water to be absorbed into the expanse of forest. Mangroves can help prevent erosion by stabilizing shorelines with their specialized root systems. Mangroves also filter water, maintaining water quality and clarity.

## Mangrove Losses In Florida

It is true that mangroves can be naturally damaged and destroyed, but there is no doubt that human impact has been most severe. Florida Department of Natural Resources, Bureau of Marine Research scientists are studying changes in Florida's coastal habitats. The scientists are able

In Palm Beach County, a 51 percent decrease in salt marsh acreage occurred in Lake Worth between 1944 and 1982 due to major land developments. A network of canals draining low-lying uplands diverted the natural flow of freshwater away from salt marsh areas.

In southwest Florida, both salt marshes and mangroves occur along the Tampa Bay shore. Since 1940, Tampa Bay has been one of the fastest growing metropolitan areas in Florida. Considerable environmental damage has occurred in Tampa Bay along with this growth. Four major types of dredging have impacted Tampa Bay during the last 100 years: channel deepening, maintenance dredging, shell dredging, and dredging for land fill construction. Ship channel dredging and port construction have brought Tampa Bay the economic benefits of being one of the largest ports in the nation. Tampa Bay has lost more than 40 percent of its original mangrove and salt marsh acreage over this time.

The elimination and alteration of Florida salt marshes have a negative effect on fishery resources. Estuaries provide nursery areas for at least 70 percent of Florida's important recreational and commercial fishes, shellfish, and crustaceans. Many of Florida's marine fisheries will decline and may disappear without coastal wetlands.

State regulations have been enacted to protect Florida's salt marsh systems. Specifically, the Warren B. Henderson Wetlands Act of 1984 es-

tablished clear guidelines for defining wetland areas that come under state jurisdiction. All dredging and filling activities in state waters require permits unless specifically exempted. Local laws vary so be sure to check with officials in your area before taking any action.

Salt marshes are a part of our State heritage. It is up to us to ensure them a place in Florida's future – your future.

For more information about Florida's Salt Marshes, write to:

**Florida Department of Natural Resources**  
**Bureau of Marine Research**  
P.O. Box F  
St. Petersburg, FL 33731



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# FLORIDA SALT MARSHES



## What Are Salt Marshes?

Salt marshes are coastal wetlands rich in marine life. They are sometimes called tidal marshes because they occur in the zone between low and high tides. Salt marsh plants cannot grow where waves are strong but they thrive along low-energy coasts. They also occur in areas called "estuaries," where freshwater from the land mixes with sea water.

A distinctive feature of salt marshes is the color – the plants are various shades of gray, brown, and green. Salt marshes are composed of a variety of plants: rushes, sedges, and grasses. Florida's dominant salt marsh species include: black needle rush (*Juncus roemerianus*), the grayish rush occurring along higher marsh areas; saltmeadow cord grass (*Spartina patens*), growing in areas that are periodically inundated; smooth cord grass (*Spartina alterniflora*), found in the lowest areas that are most frequently inundated; and sawgrass (*Cladium jamaicense*), which is actually a freshwater plant that sometimes grows along the upper edges of salt marshes. All are tolerant of the salt in sea spray.

Salt marshes are important for many reasons. Hidden within the tangle of salt marsh plants are animals in various stages of life. Animals can hide from predators in marsh vegetation because the shallow brackish area physically excludes larger fish. Many of Florida's popular marine fisheries species spend the early part of their lives protected in salt marshes.

Young fish often have a varied diet, foraging for food in the muds of the marsh bottom, on



©Tom Cross 1985

the plants themselves, and on smaller organisms that also dwell in the marsh system. As salt marsh plants die and decompose they create organic detritus, another food source for many marsh dwellers. Tidal waters move up into the marsh and then retreat, distributing detritus throughout the estuary. Algae are also an important food source in salt marshes.

## Florida's Salt Marshes

Salt marshes form along the margins of many north Florida estuaries. Gulf coast salt marshes occur along low energy shorelines, at the mouth of rivers, and in bays, bayous, and sounds. The Panhandle region west of Apalachicola Bay consists mainly of estuaries with few salt marshes. However, from Apalachicola Bay south to Tampa Bay, salt marshes are the

main form of coastal vegetation. The coastal area known as "Big Bend" has the greatest salt marsh acreage in Florida, extending from Apalachicola Bay to Cedar Key. South of Cedar Key salt marshes begin to be replaced by mangroves as the predominant intertidal plants. On the Atlantic coast, salt marshes occur from Daytona Beach northward.

Despite their value, salt marshes are too often considered to be worthless. Salt marshes provide nursery areas for fishes, shellfish, and crustaceans. These plants have extensive root systems which enable them to withstand brief storm surges, buffering the impact on upland areas. Salt marshes also act as filters. Tidal creeks meander through the marshes transporting valuable nutrients as well as pollutants from

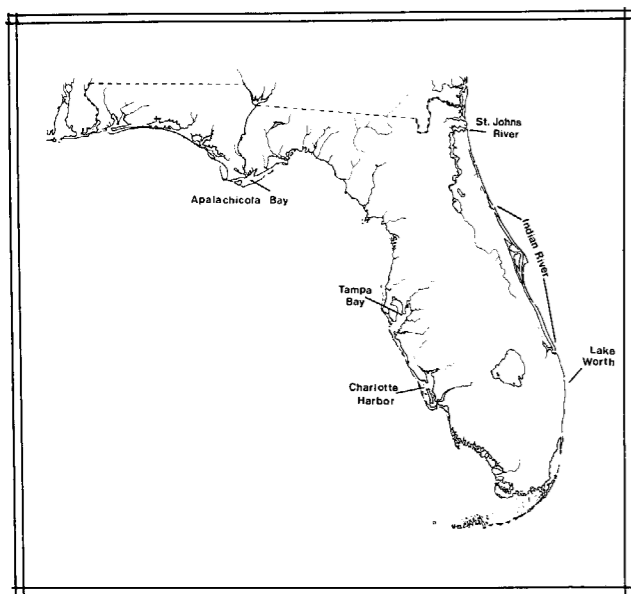
upland development. Salt marshes can absorb, or trap, some of these pollutants, reducing the pollutant load entering estuaries. Salt marshes also prevent sediments from washing offshore, often creating more land on which salt marshes can grow.

## Salt Marsh Losses in Florida

Salt marsh systems are dynamic, constantly changing. Society, however, emphasizes stability and permanence. As a result, salt marshes have been drained or filled with silt, sand or refuse to an elevation at which they can no longer survive. It is estimated that in Florida at least 60,000 acres, or 8 percent, of estuarine habitat has been lost to permitted dredge and fill activities.

The Florida Department of Natural Resources, Bureau of Marine Research is studying changes in Florida's coastal habitats. Scientists can evaluate changes by comparing aerial photographs of the coast in the 1940's, 1950's and 1980's. The changes observed too frequently show loss of fisheries habitats.

Salt marsh loss has occurred in Florida's five northeast counties which contain 11 percent of the State's total salt marsh acreage. The primary loss in Nassau County occurred because of dredging for the Intracoastal Waterway. Duval County has been impacted even more severely by human activity. Extending 3.5 miles on either side of St. John's Inlet and 10 miles up the St. John's River, analysis indicated a 36 percent loss of marsh habitat. The loss is primarily due to dredge and fill of marsh habitat since 1943.



Some Major Florida Estuaries

Florida's coast is available from LANDSAT satellite and other satellite information sources. The scientists are also noting trends in habitat change by analyzing aerial photographs from the 1940's, 1950's, and 1980's. Results of the habitat trend analyses have shown substantial losses of fisheries habitat throughout Florida. One study area on the east coast included the Indian River from Sebastian Inlet south to the St. Lucie Inlet. Over a forty year period, an 86 percent decline in the availability of mangrove habitat to fisheries was documented in addition to a 30 percent loss of seagrass acreage. Tampa Bay, in southwest Florida, has experienced an 81 percent loss of seagrasses and a 44 percent loss of mangrove and salt marsh acreage over a 100 year period.

Estuarine habitat loss is a serious problem in Florida's coastal zone. It is difficult to put a price tag on estuaries, but without question

they are one of our greatest natural resources. This resource, however, can be destroyed. The coast's appeal is very evident; 78 percent of Florida's estimated 11 million residents live in the coastal zone. Dredge and fill operations for waterfront homesites and seawall construction destroy mangrove shoreline and underwater grassbeds. Though these activities may temporarily enhance real estate value, ultimately they may decrease long-term value as the natural amenities disappear, the water becomes foul, and wildlife leaves. These activities often eliminate habitat and feeding areas for young fish, shrimp, and crabs. Without estuaries many important fisheries will disappear.

*Estuaries are special. Help protect them.*

For more information about Florida's Estuaries, write to:

**Florida Department of Natural Resources  
Bureau of Marine Research  
P.O. Box F  
St. Petersburg, FL 33731**



This public document was promulgated with state and federal funds at a cost of \$9480.31, or \$.05 per copy, to provide information about the coastal zone.



## What Are Estuaries?

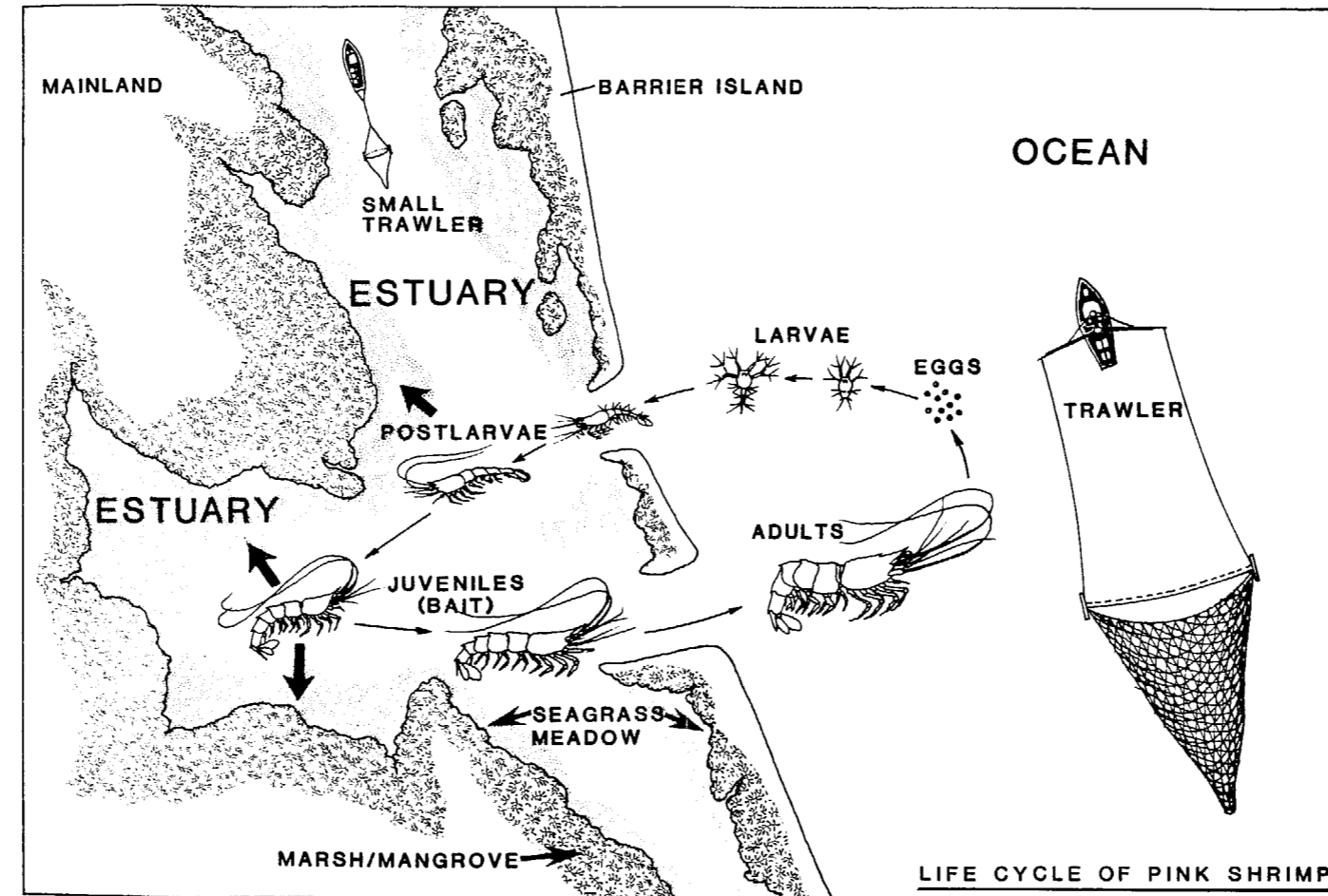
Estuaries are special. They occur in areas where freshwater meets and mixes with salty ocean waters. The term estuaries, according to general usage, refers to protected, nearshore waters such as bays and lagoons.

Survival of plants and animals in estuaries requires special adaptations. Estuaries are dynamic systems where waters are alternately salty and fresh. The ebb and flow of tides may leave some plants and animals, such as seagrasses and oysters, temporarily high and dry. Shallow estuarine water temperatures can range from freezing to more than 100° F during the course of a year.

Estuarine organisms are naturally adapted to withstand these ranges in salinity, tides, and temperatures. They must, however, have a balanced flow of fresh and saltwater. This balance can be upset if 1) there is too much freshwater, as when causeways are constructed impeding the free flow of tides; or if 2) there is too little freshwater, as in the diversion or damming of a river. Estuarine-dependent marine life may die if the precarious balance of fresh and saltwater is not maintained.

## Why Are Estuaries Special?

"The cradle of the ocean" is a most appropriate title for estuaries. More than 70 percent of Florida's recreationally and commercially important fishes, crustaceans, and shellfish spend part of their lives in estuaries, usually when they are young. Many fishes and crustaceans migrate offshore to spawn or breed. The eggs develop into larvae (immature forms) that are transported into estuaries by tides and cur-



Artwork by Mangrove Systems Inc.

rents. The shallow waters, salt marshes, seagrasses, and mangrove roots provide excellent hiding places from larger, open-water predators. Some species grow in estuaries for a short time; others remain there for life.

Shrimp, for example, spawn offshore. The larvae then move toward inshore waters, changing form by molting as they progress through various stages of development. As young shrimp, they burrow into the sea floor at the mouth of the estuary as the tide ebbs, then ride into the estuary on the incoming

tide. If successful in reaching the estuary after this hazardous journey from the sea, the young shrimp find seagrasses and algae to conceal them from predators. Because many larger animals cannot survive in the lower salinity of the estuary, the young have the added protection of a "salt barrier." Once the shrimp approach maturity, they leave the estuary for the sea to spawn, and the cycle begins anew.

Estuaries are among the most productive ecosystems in nature. Rivers and streams drain into estuaries, bringing in nutrients from up-

lands. Plants use these nutrients, along with the sun's energy, carbon dioxide, and water to manufacture food. Among the most important plant forms that contribute to estuaries are microscopic algae called phytoplankton. Other plant forms include marsh grasses, mangroves, seagrasses, and macroalgae. When these larger plants die, they are broken down into detritus and are colonized by microbes (bacteria, fungi, and other organisms). During decomposition, detritus becomes smaller and smaller and the nutrients and small particles become food for thousands of organisms. Larger animals feed directly on these tiny particles or on smaller animals that fed on detritus.

As long as nutrient-rich freshwater flows and tides interact without human interference, our estuaries will remain productive. Snook, trout, mullet, jack, grouper, redfish, silver perch, spot, catfish, sheepshead, spiny lobster, shrimp, crabs, oysters, and clams are examples of the diverse marine animals dependent upon healthy estuaries. Estuaries also provide breeding and nesting areas, or rookeries, for many coastal birds, including several endangered species such as brown pelicans. Estuaries' role as the ocean's nurseries cannot be overemphasized.

## Florida's Estuaries

Florida is undergoing tremendous growth and development pressure which is impacting marine fisheries habitat components important in maintaining viable commercial and recreational fisheries. Florida Department of Natural Resources, Bureau of Marine Research scientists are locating and calculating the acreage of existing estuarine habitat components such as salt marshes, mangroves, and seagrasses. Information used to map and monitor